

PHILOSOPHICAL  
TRANSACTIONS.

Giving Some

ACCOUNT

OF THE

*Present Undertakings, Studies and Labours*

OF THE

INGENIOUS,

In Many

Considerable Parts of the WORLD.

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VOL. XXX. For the Years 1717. 1718. 1719.

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To the Right Honourable

**T H O M A S**  
**Lord PARKER,**

Baron of *Macclesfield*;

**Lord High Chancellor**  
**Of Great-Britain:**

By INCLINATION as well as OFFICE,  
First PATRON of Useful Arts and  
Discoveries.

This THIRTIETH Volume  
OF THE  
**Philosophical Transactions**

(As a *small* Acknowledgment for  
*very Great Favours*)

Is Humbly Inscrib'd by

*His Lordship's most obliged Servant,*

*Edmund Halley, R. S. Secr*

# PHILOSOPHICAL TRANSACTIONS.

For the Months of January, Febr. and March, 1717.

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I. *Observationes Stellæ fixæ in Geminis à corpore Jovis occultatæ, Januarii 11mo. St. vet. 1717. & Transitus arētissimi Martis infra Borealem in fronte Scorpii Febr. 5. mane.*

**A**NTE biennium in *Transact. Philos.* No. 344. pag. 294, rerum cœlestium studiosis indicavimus, *Jovem* corpore suo stellam quandam fixam obtegere debere, eosque ad observationem Phænomeni rarissimi, & magno in Astronomicis usui futuri, invitavimus, signantes diem *Januarii* hujus anni decimum. *Jove* autem pene Stationario, & paulo amplius in orientem quam per Tabulas nostras provento, non ante undecimum incidit prædicta Occultatio; quam quidem *Londini* ob Nubes non contigit ex voto observare

Nec tamen frustra invigilarunt Astronomi nostri. D. *Martinus Folkes Londini*, præsentibus aliis nonnullis e Societate Regia, *Jan.* undecimo 8h. P. M. vidit *Jovis* centrum una diametro corporis ejus Fixam sequi, quæ dicto centro Borealis erat quasi dodrante semidiametri *Jovis*. Postea Nubes *Jovem* occuparunt, sed, habita ratione motus *Jovis*, paulo post medium Noctis stellam *Jovi* conjunctam fuisse, & a Borea dilci ejus parte occultatam, conclusit.

Reverendus Dominus *J. Theoph. Desaguliers*, R. S. S. & D<sup>nus</sup>. *Stephanus Grey*, *Westmonasterii*, viderunt Fixam, Horâ Sextâ vespertina, integra *Jovis* diametro distare a limbo ejus, Corum versus. Unde & ex sequentium dierum Observationibus, circa medium noctis incidisse conjunctionem evincitur

Reverendus quoque D. *J. Pound*, apud *Wansted*, infra scriptas nactus est observationes, quas utique accuratissimas



tissimas, Tubo scil. prælongo & Micrometro captas, huc transcribere non pigebit.

Itaque *Januarii* Quinto  $5^h. 6'$ . T. æq. Jovis centrum distabat a di $\sigma$ â Fixâ  $31'. 49''$ . quam  $5^h. 38'$ . sequebatur  $34'. 12''$  Ascensionis rectæ: simulque limbus *Jovis* Austrinus eandem habuit Declinationem cum stella.

Die autem Nono sequente  $6^h. 6'$ . Jovis centrum distabat a stella  $10'. 49''$ ; & post octo minuta erat differentia Ascensionum rectarum  $11'. 32''$ : & tum centrum Planetæ, tantillo, ita ut vix perciperetur, erat Stellâ Australius.

Die Undecimo  $5^h. 30'$ . T. æq. erat distantia centrorum  $1'. 24'$ . simulq; visa est stella quasi quadrante diametri Jovis Borealis centro ejus. Diameter autem minima *Jovis* inventa est  $0' 43''$ . Deinde Nubes.

Die vero Duodecimo  $5^h. 17'$ . erat distantia centrorum  $3'. 7''$ ; ac  $5^h. 50'$ . Jupiter stellam præcedebat  $3'. 30''$ . Ascen. Rect. Eodemq; tempore limbus Jovis Boreus eandem habuit Declinationem quam Fixa accurate.

Collatis autem his Observationibus manifestum est Fixam hanc *Jovi* conjunctam, *Januarii* undecimo  $13^h$ . circiter, non nisi  $17''$  vel  $18''$  centro ejus Borealiorem fuisse, ac proinde occultatam.

Fixa hæc, etiamsi nulli Catalogo hætenus ascripta, Locum tunc habuit  $\pi 22^\circ. 13'$ . cum Lat. Aust.  $0^\circ. 13'\frac{1}{2}$ ; Comitemque habet 17 min. eam præcedentem & 7 min. Borealiorem, sive in  $\pi 21^\circ. 56'$  cum Lat. Aust.  $0^\circ. 6'\frac{1}{2}$ , cui *Jupiter* conjungi visus est *Jan.* 16.  $6^h. 30'$ . vespери.

Sic spatio minus bimestri *Jupiter* corporaliter eclipsavit duas Fixas, cujus rei ne singulare quidem exemplum ab invento Telescopio extrat: proinde hæc observata inter pretiosissima Uranix κειμήλια, in usum Posterorum, merito reponenda sunt.

Nostra autem stellula anno 1634. *Feb.* 6. *Jovi* Stationario conjuncta, tribus ejus diametris Australior erat, observante *Gassendo*: unde constabit, calculo rite instituto, *Jovis* Nodos quoad sensum immobiles hæsisse, per 83 annos ultimo elapsos, idque ad  $2^{\text{s}}. 8^{\circ}. 35'$  a  $1^{\text{a}} * \nu$ .

Ad alteram autem Observationem Transitus *Martis* prope *Boream Frontis Scorpionis* non minus insignem, iidem Astronomi eadem cum cura invigilarunt omnes. *Mars* autem, *Februarii* Quinto Mane, vel Quarto 16<sup>h</sup>. visus est adeo vicinus stellæ dictæ, ut ea nudis oculis non conspiceretur; sed per Telescopium inventa est supra & ad ortum, adeoque *Mars* nondum ei conjunctus. Hora 16<sup>h</sup>. 10'. T. app. *Mars* erat in recta cum *Borea frontis* & Telescopicâ quæ eam sequitur ad *Boream*, ad distantiam octo circiter minutorum. 16<sup>h</sup>. 35'. *Mars* intermedius erat in recta cum *Boreâ* & *Mediâ Frontis*; & post horæ quadrantem, cum *Austrinâ Frontis*, ita ut 16<sup>h</sup>. 54'. T. app. æstimabatur Conjunctio ipsa quoad Longitudinem, quo tempore *Mars* sat accurate duobus tantum minutis australior erat stellâ. Observavit etiam *D. Pound* Conjunctionem respectu Ascensionis Rectæ 17<sup>h</sup>. 25'. T. app. cum distantia centrorum 2'. 07". Jucundum autem erat spectaculum. *Martem* videre stellam pedetentim aggredientem, motumque suum, lentissimum licet, manifeste prodentem.

Conferatur cum hac Observatio *Horroxii* nostri anno 1638. *Februarii* Septimo mane, quam vide in Epistolis ejus pag. 304. Tunc enim *Mars* ad eandem stellam appulsus, etiam multo propius ad eam accessit, sed ante ortum ejus præterierat Conjunctio.

His adde *Saturni* observationem *Januarii* 25to. 12<sup>h</sup>. 25'. T. æq. à *D. Pound* habitam. Cum Planeta distabat à stella 58va. *Virginis Catal. Brit.* 13'. 16". versus Austrum, eamque sequebatur 2'. 30". Asc. Rect. Stella in  $\approx 19\ 21'. 52''$ . cum lat. Bor.  $2^{\circ}. 47'. 25''$ .

II. *An accurate Account of a tessellated Pavement, Bath, and other Roman Antiquities, lately discover'd near East Bourne in Suffex. Being part of a Letter of January 26. 1717. from the learned Dr. John Tabor of Lewis, to Dr. John Thorpe, R. S. S. and by him communicated to the Royal Society.*

A Description of the tessellated Pavement at *East Bourne*, near *Pevensey*, must have been more imperfect than what is now given, had it come to your hands much sooner. I thought an exact Account could not be taken, unless the Ground about it was open'd: and it being part in a Meadow, and part in plough'd Ground, and under a Fence which parts two Persons Lands; by reason also the one was sow'd; I could not procure the Digging in both Places at the same time.

It was in *March* last when the Meadow was dug; and the last Week save one in *November*, before we had leave to open the Ground in the Corn Field. The Meadow in which the greatest part of the Pavement lyes, is near a Mile and half South East of *Bourne*; it contains about four Acres, and is of a triangular Form; the Southern Side is against the Sea; only a few Fishers Cottages, and a small publick House or two being between that and the Sea. On the Northern Side of the Meadow is a High-Way, which leads from *Bourne* to *Pevensey*: the West Side is by a Fence of Posts and Rails separated from a large Corn Field, in Common belonging to the Parish.

Q q q q

About

About the middle of this Fence is the Pavement, distant from High-Water-Mark a Furlong; In former times it might have been somewhat more, because from this Point to the Westward, the Sea is always gaining from the Land.

More than four Years since, *viz.* in the Summer 1712, when the Fence was repair'd; the Workman sinking a Hole to fix a Post in, was hinder'd by something Solid like a Rock; but casting out the Earth clean, found the Obstacle to be Artificial. Mr. *Thomas Willard* of *Bourne*, Owner of the Meadow, being inform'd of the Novelty, gave Order that it should be uncover'd; and sent also to *Herstmonceux*, for one *Parceglowe* an ingenious Engineer (who formerly had been employ'd in the Mines in the Northern Counties), who with his Instruments bored through the Pavement; and in many places of the Ground about it, which he found to be full of Foundations: but this his Discovery of those Foundations, was only a Confirmation of what the Inhabitants there have always observ'd, as well in Ploughing, as in the Growth of their Corn and Grass: for in the common Corn Field, West to the Meadow, to the distance of near half a Mile, they often raise bits of Foundations with their Ploughs; and in dry Summers, by the different Growth of the Corn, they can plainly perceive all that Tract of Ground to be full of Foundations.

The Pavement was little more than a Foot below the common Surface of the Ground; what lay next it was a small Sea Gravel; the Position of it is very near due East and West (about two Foot of the West end of it reaching into the Corn Field); its length is seventeen Foot and four Inches; its breadth eleven Foot. At first it seem'd to have been bounded with a thin Brick set on Edge, about an Inch above the *Tesserae*, so exactly strait and even, as if Shot with a Plane; and so well Cemented,

as

as if one entire Brick. But when the outside of the Pavement was broke up, we found, that instead of Bricks set on Edge, as was imagin'd, it was bounded with a Border of Bricks laid flat, and their ends next the *Tessera* turn'd up. The Thickness of these Bricks was an Inch and a Quarter; the Breadth not under Eleven, and not more than twelve Inches; the length full fifteen Inches; which, before they were turn'd up at their Ends, could not have been less than Seventeen. They were very firm, and not in the least Warp'd or Cast in Burning: when broke, their Substance was fine and well mixt, of as uniform and clean a Red Colour, as a piece of fine *Bole*: Except at the ends where turn'd up, they were all over cover'd with a Plaster (the same which *Vitruvius* calls the *Nucleus*, of which more afterwards), half an Inch thick; so hard, entire, and even, that it seem'd as one Stone, quite round the Pavement.

Next within the Bricks, there was a List or Border of white *Tessera*, thirteen Inches broad; within that, a List of brown *Tessera* (somewhat darker than a Whet-Stone, and somewhat lighter colour'd than the Touch-Stone) four Inches broad; then a List of the White, five Inches broad; next within that, another List of the Brown, four Inches broad: all the rest of the Pavement was set with white *Tessera*, without any Ornament or Figure; which though not Gay, lookt very Neat and Clean.

When this was first view'd, none of the Curious doubted, but that the Work was Roman, many were of opinion, that it might have been the Floor of a Temple, or place of Worship. *Pliny* indeed (a) informs us, that these sort of Pavements or *Lithostrota*, began to be in use in *Italy*, in the time of *Sylla*; who caus'd one of them

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(a) *Plin. Sec. Hist. Nat. Lib. XXXVI. Cap. XXV.*

to be made in the Temple of *Fortune* at *Praneste*; perhaps the same which not long since was taken notice of by the Honourable Mr. *Addison* ( *b* ).

I was rather inclin'd to suppose, it had been that Apartment belonging to the chief Officer where Justice was administer'd; and the more, because *Pilat's* final Sentence on our Saviour was pronounced from a Throne on the *Lithostroton* ( *c* ); which Appellation was given to these kinds of Pavements by *Varro* ( *d* ) not less than sixty Years before; and by *Pliny* ( *e* ) not less than forty Years after our Saviours Suffering. That the Roman Generals caus'd such Pavements to be made at their Stations; we may have just reason to conclude, from that passage ( *f* ) in *Suetonius* cited for this purpose by Dr. ( *g* ) *Plot.*

When the Ground about the Pavement was dug, all these Suppositions were quash'd; for on the North Side of the Pavement, we discover'd an entire Bath, sixteen Foot long, five Foot nine Inches broad, and two Foot nine Inches deep (which the Draught sent with this represents): *Fig. 1.* It was fill'd with Rubbish of Buildings, which seem'd to have been burnt; *sc.* hard Mortar adhering to pieces of Roman Brick, squar'd Stones, and headed Flint, mingled with Ashes and Coals of Wood. From the Northwest Corner of the Pavement, was the Passage into the Bath, three Foot three Inches wide; at which place, the Bricks that bounded the Pavement, were not turn'd up at their ends, but lay even with the *Tesserae*. At the distance of fifteen Inches from the *Tesserae*, there was a Fall of two Inches, to the Landing-

( *b* ) Remarks on several places in *Italy*, *Pag.* 377. ( *c* ) *Evagg.*  
*Joan.* K. XIX. 13. ( *d* ) *Ter. Var. de Re Rust. Lib.* 3.  
 ( *e* ) *Plin. Hist. Nat. Lib.* XXXVI. C. XXV. ( *f* ) *Jul. Cæs. Sect.* 46.  
 ( *g* ) *Oxfordshire Plots Nat. History, Chap. X.*

place out of the Bath ; the Landing place was also three Foot three Inches long, and two Foot two Inches broad : Thence by two Stairs, was the Descent into the Bath ; the length of the Stairs, the same as of the Landing-place ; the breadth of each Stair was eleven Inches ; the height of each Step a little more than ten Inches : the lowest Stair was twenty Inches from the farther Side of the Bath. The whole Work was very compact, and exactly well made ; not in the least injur'd by Time, nor the Violence it underwent when fill'd up ; truly answering the Precepts of *Vitruvius* ; which (*h*) advise, that for all Buildings, respect should be had to the Strength, Conveniency, and Beauty of the Work design'd ; and that in order thereto, a careful and judicious Provision should be made of Materials, without Parsimony.

Although the Author and Time of these Works cannot as yet be discover'd ; yet 'tis evident the Artificer near enough follow'd the directions *Vitruvius* (*i*) gave for framing such like Structures.

(*h*) *M. Pollio Vitruv.* de Architectur. Lib. II. Cap. III. Hæc autem ita fieri debent, ut habeatur ratio firmitatis, utilitatis, venustatis. Firmitatis erit habita ratio, cum fuerit fundamentorum ad solidum depresso, & ex quaque materia copiarum sine avaritia diligens electio.

(*i*) *M. Vitruv. Pol.* Lib. VII. Cap. I. Primumque incipiam de Ruderatione, quæ principia tenet Expolitionum, uti curiosus summaque providentia solidationis ratio habeatur. Et si plano pede erit rudendum, quærat solum si sit perpetuo solidum.—Si aut omnis aut ex parte congestus locus fuerit, fistulationibus cum magna cura solidetur.—Tunc insuper statuminetur ne minore saxo quam quod possit manum implere : statuminibus inductis rudetur. Rudus si novum erit, ad tres partes una calcis misceatur, si redivivum fuerit, quinque ad duum mixtiones habeant responsum. Deinde Rudus inducatur, & vestibis ligneis Decuriis inductis crebriter pinfatione solidetur ; & id non minus *post* pinsum absolutum crassitudine sit dodrantis. Insuper ex Testa Nucleus inducatur, mixtionem habens ad tres partes unam Calcis ; uti ne minore sit crassitudine pavimentum digitorum senum. Supra Nucleum, ad Regulam & Libellam exacta Pavimenta struantur, sive Scetilibus, seu Tesseleris. Cum ea extructa fuerint, & fastigia extructiones habuerint, ita fricentur, uti, si Scetilia sint, nulli gradus in scutulis, aut trigonis, aut quadratis, seu favis

First,

First. as to the Pavement, it was secur'd on every Side, and the Edges of it rested on a very firm and neat built Wall, made of Roman Brick, squar'd Stone and headed Flint; between five and six Foot deep below the Surface of the Pavement, and full twenty three Inches thick; which we may suppose to have been two Foot by the Roman Measure. The Bricks were not in regular courses, as they are to be seen in those Roman Buildings, which are in view above Ground; but without order dispers'd about in the Wall. The Top of the Wall indeed was but fifteen Inches thick; and that was cover'd with the Bricks first mention'd, which bounded the Pavement: but about fourteen Inches below the Top, there was a Set-off (as our Mafons term it) in the inside of the Wall, eight Inches broad. We did not dig up the Foundation of the Pavement to the Bottom, but opened it at one Corner only, that we might discover how it was Fram'd: for when it was bor'd through, they observ'd, next under the *Tessellæ*, a Bed of very strong Mortar, more than a Foot thick; under the Mortar a Bed of Clay two Foot thick; and under the Clay a firm Foundation of Brick. We observ'd the Clay (which the Ground thereabouts do not afford) to be very fine and red, and also close; no doubt but carefully Ramm'd. The Surface of the Clay was nearly pitch'd with small Flint and Stones, Pointed at their lower ends, and Headed at their upper ends. This Pitching or Paving is by *Vitruvius* call'd *Statuminatio*; and the Stones 'tis done with, he

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extent. Sed coagmentorum compositio planam habeat inter se directionem. Si Tessellis struñum erit, ut eæ omnes angulos habeant æquales, nullibique à fricatura extantes. Cum enim anguli non fuerint omnes æqualiter plani, non erit exacta ut oportet fricatura.

calls



calls *Statumina*. He directs them to be set, when the Underwork is made Sound and Firm, by well Ramming. Because the first Chapter in his Seventh Book, treats only of the Method of making these kinds of Pavements, which in his time, and as may be observ'd from his words, were had in no small esteem by the Grandees of *Rome*; I have transcribed what may shew the accurate Methods which that great People had in Framing them.

But to return, this pitch'd Work was exactly even with the Set-off in the inside of the Wall; on it was laid a Bed of coarse Mortar of about nine Inches thick; the Skirts of this Mortar (which by *Vitruvius* is call'd the *Rudus*) rested on the Set-off above-mention'd; it was compos'd of Lime, a sharp coarse Sand, small Pebbles, and bits of Brick. Upon this *Rudus* was a finer Composition, made, as near as I could guess, with Lime, a fine sharp Sand, some kind of Ashes, and (which was the greater part) stamp Brick and Pot-sherds, in grains not larger than Cabbage-Seed, and the Flower or fine Powder separated from it. This Bed was about half a Foot thick; and is what *Vitruvius* calls the *Nucleus*. Whether we may call it Terrace, I must leave it to those who are better skill'd than my self, in giving proper Appellations to the several parts of Masonry. Both this *Nucleus* and the *Rudus* under it, very near equall'd the *Portland-Stone* in hardness and compactness. Upon this *Nucleus* or Terrace were the *Tessera* set: they were set an end; but so exact was the Workman in setting them, that he us'd two sorts of Cement to fix them withal; their lower ends stood in a Cement of Lyme only, well work'd; their upper halves were cemented with a fine gray Mortar, consisting of fine Sand (and as it seem'd) Ashes and Lyme. This gray Cement every where fill'd the Intervals at their Heads; and was much harder than the *Tessera* themselves.

'Twas

'Twas before intimated, that the *Tesserae* were but of two Colours, White, and of a dark Brown; they were harder than a glaz'd and well burnt Tobacco-Pipe, and of a Grit somewhat finer; the Brown seem'd to be of the same Substance with the White, but colour'd by Art, (as *Pliny* informs us (*k*) the workers in Clay of old had a Method to do): they seem'd to have been form'd in a Mould, and afterwards Burnt. Hence I am inclin'd to take the meaning of *Vitruvius*; where he makes so plain a distinction between the *Tesserae* and the *Scutellia*; that, the one was according to the import of the name, form'd by Instruments out of Stone, Brick, and Tyle; the other shaped in a Mould and Burnt. They were not of an equal Size, none exceeding an Inch in length; the shortest were  $\frac{6}{10}$  of an Inch: most of them were equally made their whole length; but of some the lower ends terminated almost as sharp as a Wedge, on purpose, as may be suppos'd, to be driven where any Interstices were left: At their Heads likewise they were not all equal and alike, some exactly Square, some oblong Square, some Semi-lunar, but none Triangular: the Diameter of those that were Square was about  $\frac{4}{10}$  of an Inch; the longest Side of those that were oblong at the Head little exceeded half an Inch. It may be observ'd, that the preparations for fixing this Pavement here, go beyond those which *Vitruvius* prescribes (in the firm Wall near six Foot below the Surface, in the Bed of Clay within it two Foot thick, and in the Foundation of Brick under the Clay). But when we consider the Situation of the Ground here is low, not many Feet higher than the Sea might be elevated at Spring Tides; and that it might as well be annoy'd by Land-Springs after great Rains, as by Water owzing through the Earth from the

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( *k* ) *Plin. Secun. Hist. Mund. Lib. XXXVII. Cap. XII.*

Sea so near; from which the Work in time might receive damage; we must allow the abovemention'd Additions to be the result of a very judicious Foresight.

The Bath also was form'd and secur'd by a very compact Wall, of the same breadth and depth with that on which the Pavement rested: the Wall, which sustain'd the North Side of the Pavement, made the South Side of the Bath. On the South Side of the Bath, from the East end, to the ends of the Stairs, there was a solid Seat; twelve Foot nine Inches long, very near ten Inches broad, and fourteen Inches high. The Bottom or Floor of the Bath, was made after the same manner as the Pavement was made, excepting the *Tesserae*, and the thick Bed of Clay: for under all, there was Brick; then a Bed of the *Rudus* or coarse Mortar somewhat more than a Foot thick; above that the *Nucleus* or Terrace only, half a Foot thick. The Sides of the Bath, the Seat, and the Stairs, were plaster'd over with this Terrace about half an Inch thick; all which were throughout so Hard, Compact, and Smooth, that when first open'd, the whole seem'd as if it had been hew'd out of one intire Rock, and polish'd. At the middle of the East end, at the Bottom, there was a Sink-hole, a little more than three Inches long, and above two Inches deep: about four Inches above it, there was another passage through the Wall of the same size; the first we may suppose to let out the Water which had been us'd; the other to let in fresh. The Stairs and Seat were chiefly made of *Roman* Brick, between fifteen and seventeen Inches long, between eleven and twelve broad, and near one and a half thick. At the North Side of the Bath the Ground was not open'd; but at the East end of the Bath and Pavement, at the South Side of the Pavement, and at the West end of both, there seem'd to have been several Vaults or Cellars: for there were

very firm 23 Inch Walls continued every way (to the farther ends of which we did not trace), whose Foundations were as low as that which supported the Pavement: so that to the depth of six Foot the Ground was fill'd with such Rubbish as was taken out of the Bath. The Bricks in this Rubbish, which were all broke, had several degrees of thickness, from three Inches to a little more than one Inch: some had one of their Sides wav'd as in *Fig. 2*; some fretwise as in *Fig. 3*, others had Roes on them well imitated: we found also two sorts of channel'd Bricks; the one like a Trough, the Channel three Inches broad, and as many deep, the Brick it self an Inch and a half thick: The other sort, had a Cylindrical Channel; so that when two were clapt together, they form'd a hollow Cylinder of three Inches Diameter. These channell'd Bricks being all broken, their Length when whole is uncertain, as is the Use they serv'd to; whether for Passages to convey Water; or whether they were placed in the Walls to distribute Heat throughout the Building, as was usual in the ancient Structures at *Rome*.

'Tis farther observable, when the Ground was open'd the second time; that off from the South-West corner of the Pavement, which the Letter *G* shews; five Foot lower than the Surface of the Pavement, there was discover'd a large Space (to the end of which we did not search), paved with Brick, eleven Inches broad, almost one and a half thick, and fifteen long; substantially was it pav'd; for it had two Courses of this Brick. There was half a Foot of Mortar under the lower Course; and about an Inch of Mortar between the two Courses; these Bricks also were perfectly well made; but on the under Side of each, were two Knobs, about the size of half a Walnut; fix'd on them as may be guess'd,

to keep them steddly, till the Mortar they were set in might dry. This pav'd Place was searcht 6 or 8 Foot every way; it was all cover'd with a Coat about two Inches thick, of Ashes and large Coals of Wood: on that lay confusedly large pieces of the *Rudus* or coarse Mortar abovemention'd, and lumps of the *Tissera* in all respects like those on the Pavement, and cemented as They were. There were moreover mingled with the Ashes many large Iron Nails, bigger, but not quite so long, as those we call double Tennes; some Hooks for Doors to swing on; several small pieces of earthen Ware; some like bits of Urns; some of a fine yellow Clay; some red, thin, neatly wrought and adorn'd with Flowers; and lastly part of a Human Skull, and pieces of Bones near it; which Bones were not inclos'd in any Vessel, but lay loose; they were discolour'd like those I have seen in Urns; so that the Body they belong'd to, might perish by the same Flames, that these Buildings were destroy'd by. There was no Inscription found either on Stone or Brick; no Statue, or other Figure, save those on the Bricks mention'd; neither were there any Coins met with there. But something more than a Furlong North-West of these Works, near three Years since, there was a Malt House, and near two Years since a Dwelling-House erected; in digging the Foundations for the first, there was a Coin of *Posthumus*; and in the Ground dug for the last, a piece of *Constantine's* found; both which I send with this, that the Inscriptions and Reverses may be incerted if necessary.

From the nearness of the Bath, it may reasonably be concluded that the Pavement was neither a part of a Temple, nor for a place of Justice: the continuation of the Foundations every way to be traced from it, and what was last discover'd, are rather an Argument it was an Apartment of a magnificent Palace.

*Pliny* supposed that these *Lithostrota* ( *l* ) or tessellated Pavements had their original in *Greece*; but perhaps the *Grecians* borrow'd their Patterns from *Asia*: for from the Book of *Esther* ( *m* ) we learn, there was a most Royal Banquet at *Susa*, on a *Lithostroton* (so the Septuagint has it) of costly Stones, four Hundred Years before the time of *Sylla*, who brought them first into *Italy*. *Josephus* affirms ( *n* ), that the *Grecian* Laws, Learning and Arts were fetch'd from *Asia*: and indeed when we reflect on the Antiquity of the *Levitick* Law; the Pyramids of *Egypt*; the Temple of *Solomon*; the Walls and Palaces of *Babylon*; and the sumptuous remains of *Palmyra* and *Persepolis*; we have no reason to esteem the *Grecians* Authors, but as good imitators of those early Examples of Learning and Arts they had to follow.

When *Quinctus Cicero* was here with *Cæsar*, the second time he invaded *Britain*; his Brother the incomparable *Tully*, had the oversight of some Buildings he had appointed to be made in the *Villa Manliana* at *Arzano*: and in a Letter sent into *Britain*, *Tully* informs *Quinctus*, that he was well pleas'd with the Seat, and the more, because the Pavimented Piazza was Magnificent: that the Pavement seem'd ( *o* ) to be exactly well made: that he had directed some Chambers to be alter'd because he did not approve of them: that in the Bathing Apartment, he had remov'd the Sweating Room into another corner of the *Apodyterium*. And afterwards in the same Letter makes mention of such another Work which was in hand for him in the City also. Again, about the time *Quinctus* return'd out of *Britain*, and was fixt with the Legion he presid'd over, in Winter Quarters

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( *l* ) *Plin.* *Señt. Hist. Lib.* XXXVI. *Cap.* XXV.

( *m* ) *Esth.* *Chap.* I v. 6.

( *n* ) *Joseph against Appion.* *Book* II.

( *o* ) *Tull. Cic. ad Quinct. Frat. Lib.* III. *Ep.* I.

among the *Nervii* (of which *Cæsar* in his Commentaries makes mention) ; *Tully* ( *p* ) takes notice of a Pavement that was making for himself also : *Expolitiones utriusque nostrum, sunt in manibus ; sed tua pæne ad tectum jam perducta res est rustica Arcani & Laterii*. 'Tis hinted by *Varro* that a *Lithostroton* was one of the Members of a compleat *Villa* ( *q* ) : *Varro* was eighty Years old when his Books *de Re rustica* were composed : *Tully* was something more than fifty when the above cited Epistles were wrote ; *Cæsar* when a General, made the *Tessere* ( *r* ) and *Secilia* for Pavements, to be part of his Baggage ; and *Vitruvius*, Cotemporary with these three, calls the *Lithostrota*, *Principia Expolitionum* ( *s* ) ; which make it evident these Floors were held in esteem, by as great Men as the World has afforded, even in their riper Years : From all this, we may observe, that sometime before, and in the first Age of the Empire, the humour of these kinds of Floorings much prevail'd among the *Romans* : wherefore 'tis no wonder they are found in so many places of this Island. But, as unprofitable Inventions and Customs in time grow Stale, and are laid aside, so fared it with that of Pavements : For in the time of *Pliny* they began to be out of use on the Ground ; but then he tells us, they were made above Stairs ( *t* ), or in his own Words in Chambers. Whether the *Lithostrota* in Chambers were usual in *Vitruvius*'s days, we have no Warrant to suppose, from any hint in his Writings ; notwithstanding he gives Rules for making them, *plano pede*, on the Ground ; and *sub* ( *u* ) *dio*, (which

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( *p* ) Ibid. Ep. I I.

( *q* ) Ter. Varro de Re rustic. I lib. III.

( *r* ) Suet. Tranq. Jul. Cæs. Cap. 46.

( *s* ) M. Vitruv. Pol.

Lib. VII Cap. I.

( *t* ) Plin. Hist. Lib. XXXVI. Cap. XXV.

Pulsa deinde ex humo Pavimenta in cameras transiere è vitro : novitium & hoc inventum.

( *u* ) M. Vitruv. Lib. VII. Cap. I. Sub dio vero

maxime idonea faciunda sunt pavimenta.

from the Method by him prescrib'd must be) aloft: because for sustaining those *sub dio*, he orders the work underneath to be well secur'd, with two lays of Plank that should cross (w) each other, and be nail'd down; then the *Statuminatio* or Pitching, the Mortar, Terrace and *Tesserae*, as before on the Ground. But because by *sub dio* *Vitruvius* could not design Chambers; and although *Pliny* informs us the *Gracians* us'd (x) to cover or Flat-roof their Houses with these Pavements; yet since neither *Vitruvius* nor *Pliny* mention any such Mode prevailing in their times at *Rome*; it remains, that we may imagine *Sub dio*, or the *Subdialia* of *Vitruvius*, to mean Pavements mounted on Pillars or Arches, which might afford delightful Terraces out of the upper Rooms, and shady Piazzas underneath: and in this Sense perhaps may be understood the *Porticus Pavimentata* of *Tully* above-mention'd. By the many Apartments, the Foundations about these Works point out, there seems to have been nothing wherein the Buildings that once stood there, might come short of the magnificent Structures, wherewith the *Romans* delighted to gratify their Luxury. The uses each were design'd for, is not to be determin'd: whether there was a Piazza cover'd with a *Lithostroton*, cannot be affirm'd. But be that as it will; 'tis next to Demonstration, there was some upper Floor sustain'd by Wood, and pav'd with the *Tesserae*, after the same manner as *Vitruvius* directs; and, on the Brick Pavement (last discover'd), the Coat of Ashes and Wood Coals with Nails, cover'd with large pieces of the *Rudus*, and great lumps of the *Tesserae* well cemented

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(w) Ibid. itaque si necessitas coegerit, ut minime vitiosa fiant sic erit faciundum: cum coaxatum fuerit, super altera coaxatio transversa sternatur, clavisque fixa, &c.---Statuminatione facta rudus inducatur, &c.

(x) Plin. Hist. Lib. XXXV. Cap. XXV. Subdialia Græci invenere talibus domus contegentes.



together, and the *Nucleus* adhering to them; shew there was an upper Pavement broke by its fall, when Fire had consum'd its support.

I have been thus prolix, in giving you the most exact account I could of this piece of Antiquity; because we cannot have a less Sense of the admirable Rules and Methods, the *Roman* People made use of, in framing their Buildings, and ordering other Conveniences for Enjoyment and Magnificence; than of the incomparable Management they had in their Military Preparations and Discipline; which are so to the Life represented by (y) *Josephus*, and so punctually described by (z) *Vegetius*.

As to the *Roman* Architecture, it may not be amiss here to note; that when they design'd a Building, they could not immediately begin it: their Preparations requir'd time: By their well shap'd durable Bricks, and by their Stone-like Mortar, we may plainly perceive, they built not with such hasty Materials as are now us'd. *Vitruvius* (a) and *Pliny* both direct, that Brick should be form'd in the Spring, and be two Years drying. And where *Pliny* speaks of their Mortar, he says, 'twas ordain'd by the old Laws (b) of *Rome*, that no Undertaker should Build a House with Mortar which had not been made three Years before. We find indeed, their Walls seem to bid fair for Eternity; whereas ours, from Parsimony and ill Management, are scarce able to endure one Age.

*The rest of this learned Discourse, by which 'tis made more than probable that here once stood the Roman City Anderidæ, destroyed by the Saxons about the Year 500; though very curious, yet being chiefly Historical, seems not so properly the Subject of these Transactions.*

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(y) *Josephus's Wars of the Jews*. Book III Chap. III.

(z) *Veget. de Re Militari*.  
*Plin Hist. Lib. XXXV. Cap. XIV.*  
*Lib. XXXVI. Cap. XXIII.*

(a) *M. Vitruv. Pol. Lib. II. Cap. III.*

(b) *Plin. Hist.*

III. *A short account of the Nature and Vertues of the Pyrmont Waters ; with some Observations upon their Chalybeat Quality. Communicated by Dr. Frederick Slare, R. S. Soc.*

**H**AVING procur'd about a dozen Quarts of *Pyrmont* Waters this last Summer, I made some Tryals with them. I found by the Taste that they contain'd a rich Chalybeat Vertue, and also made a very brisk and lively impresson on the Palate, more grateful and spirituous, than the best *Spaw* Waters I ever tasted. The *Spaw* Waters are look'd upon as most excellent, if they Sparkle a little in the Glafs; but these in Summer time, when pour'd into the Glafs, nay sometimes even in the Bottle, as soon as the Cork was open'd and the Air was admitted, would make a notable Ebullition, somewhat like bottled Cyder, tho' this was soon over; but they did yet continue their smart and brisk Taste, and high Chalybeat Relish to the last Drop, tho' we were some Hours in Drinking them off. In the Winter time, these Waters do not Sparkle, nor Ferment, at least mine did not; but they were not carefully preserv'd, being expos'd in cold Cellars, where our Beer or Wine stood in the Winter; and yet notwithstanding, they lost not the Chalybeat Taste, and also retain'd a very pleasant brisk Gust. These Waters have been reckon'd in the Number of the *German Saur Brunnen* or *Acidule*, and some of my Friends to whom I gave a Glafs of the Water, have ascrib'd to it a sharp Taste, and have been ready to run away with a posses'd Opinion of its being Sour: but when I requir'd them to call back that hasty Assertion, and to consider it better, whether that Taste was really

Sour or Acid, they have been forc'd to recant and confess, that the smart and brisk Taste misled them to call it Acid or truly Sour. Thus Cyder and soft Ale when Bottl'd, will give such an acute Affection to the Palate, when it is far from being Sour: And even *Volatile Alkalies* of *Sal Armoniac* or of Hartshorn, may be made to give the like pungency to the Tongue.

In order to a more nice Enquiry, whether any Acidity were discoverable in these *Pymont Waters*, we dropt in considerable Quantities both of Spirit of Hart-horn, and of Spirit of *Sal Armoniac*, both justly prepar'd; but could not discover the least Luctation or Motion to appear upon this Conjunction, as it usually does with an Acid.

I made a yet more nice and certain Examen of these Waters, by mixing Milk with them, sometimes in equal, sometimes in double proportion; and in various degrees of Warmth, both in Lukewarm degrees, and also with a boyling Heat, but I could not perceive any Curdling. But rather on the contrary, the Water preserv'd the Milk from Coagulation, for four or five Days, even in *September*, it being hot Weather.

Take a very little Gall in Powder, about half a Grain to a Glass of a quarter of a Pint; this does in a Moment render it turbid, and make a dark Purple, especially if you stir it: but if you drop the Powder on the Surface of the same Water, it then causes a fine blew Tincture. If you will make a very fine Tincture pleasant to the Spectator, Take five Leaves of strong Green Tea, put them into the bottom of a Glass holding a quarter of a Pint. and you will see those Leaves unfold themselves, and in a quarter of an Hour, tinge the Water with such a Cerulous azure Blue, that few Vegetables do afford the like. We observe, that the longer these Leaves, or any other Stipticks, (which are the

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Preci-

Precipitators) do stay together, the more they degenerate into a deep Purple, or even to an Atramentarious Colour.

In reference to the internal Use of these Waters, I drank about a Quart at a time, after this manner. I first began with the *Spaw* Waters, which I procur'd very good, and drank them for a Week, and they agreed very well. I then drank the *Pymont* Waters for three or four Days, and continu'd the use of these Waters alternately, until I had drank about twenty Days. By the result of my Experiment it seem'd to me very plain, that the *Pymont* Water was more agreeable, gave more Strength and Spirit, and was as much or more preferable for its internal Vertue, as for its excelling the other in a brisker and more sprightly Taste.

There is another Excellency in these Waters which will make them more useful to us, than any Foreign *Chalybeat* Waters we yet know, because these will keep better; they are not so soon spoil'd by any accidental Insinuations of Air, as the *Spaw* are subject to be. The *Chalybeat* Mineral is here thoroughly dissolved and well united, and mix'd in this Water, so that it does not easily precipitate: for which Reason it may also the better pass the *vasa lactea*, and even enter into the Mass of Blood it self, and work the more considerable Effects. That this is not a bare Hypothesis may be prov'd by this Experiment.

Having suffer'd the *Spaw* Water to be expos'd in a Bottle which was half full, and unstopt 12 Hours, I examin'd it, and found it tast just like common Water; but the *Pymont* Waters that were open'd to the Air after the same Manner, tasted strong of the Mineral, and gave their Tincture as at first; nay, they continued thus for full two Days, and perhaps might have done so longer, but I thought that Time suffic'd.

There

There remain several other Experiments to be made, in order to a further Search into the Excellencies of this noble Water, but this I cannot do at present for want of a Quantity, which I hope to obtain the next Summer; for they can with more Ease be brought into *England* than the *Spaw*. I may also fairly conclude, that since the *Spaw* has been very beneficial to our Patients in Chronical Diseases, these Waters of a much superior Virtue will surpass them in conquering many of our obstinate Distempers.

*Some Additions to the aforesaid Account of the  
Pymont Waters*

HAVING had lately some Discourse about a Purging Quality contained in these Waters, I am now inquiring into the Truth of this Question, whether they in Reality do contain any Purging Ingredients or Properties.

I evaporated about a Quart of this Water *ad siccitatem*; I then poured on the *reliquia* some Rain-Water, enough to dissolve and take up the Salts, and exhal'd that Water, and had a Grane or two of the Salts, that tasted *muriatic*, such as most River and Pump Waters give. It is well known that the Purging Waters have a very bitter Taste, and by the most learned Doctor *Grew pie Memoria*, and an illustrious Fellow of this Society, that Salt was called *Sal Catharticum amarum*, which distinguish'd it from all other Species of natural Salts: that of the *Pymont* Water abovementioned has no Relation to this, but to the Sea-Salt, not being in the least bitter.

It is also well known, that unless our Waters be impregnated with a considerable Quantity of this bitter Salt, it will not purge at all: Two or three Granes signifie nothing, nor have the least Cathartic Power. For Example, Put two Drams of the purging Salts to a Quart of common Water; and this Quantity will give but a Stool or two to one who is naturally very easie to work upon. I have examin'd several other *Chalybeat* Waters, and found much the like Ingredients, and never any that I could suspect to carry any purging Properties.

I think we can much better demonstrate that the *Chalybeat* Waters do contain Stiptic and Restraining Virtues, because they owe their Birth to the *Iron Mineral*, and more particularly to the *Pyrites*, which Doctor *Lister* suggests, (not without some Reason) to be the Parent even of all *Iron Oars*, as it is doubtless the Cause of all *Chalybeat* Waters: Thus I have often examined the Solution of the *Pyrites* by the Rain-Water at *Oxbford*, and at other Places where *Copperas* is made, and found it a very strong *Chalybeat* Water. It is from this *Minera* we have our strong Stiptic and constringent Medicines, for external and internal use; we have our Powders and Salts of *Steel*, or *Vitriol of Mars*, from hence; nay, even those obstinate and inveterate *Diarrheas* which have baffled the Force of all Medicines, have, by a judicious Use of *Tunbridge* and other Iron Waters, received a Cure.

But notwithstanding all we can say, it will be retorted, that there is Matter of Fact and Experience against us, that the Waters really do purge at *Pymont*, where they are drank.

This we do allow to be true, that *Tunbridge* Waters do not only purge but sometimes vomit. when drank hastily and in great Quantity; but our Physicians have  
cor-

corrected this Irregularity, and we hear of no such Complaints, where they observe a just *Regimen*: And we do all agree, that those Waters are, in their own Nature, binding, and do oft require some opening Medicine. The Quantities of Water drank at *Pymont* are very large, often two or three *English Quarts*. It is no Wonder that their Weight forces them thorow the Bowels; for any common Water, drank hastily, and in such Quantity, will do the same. Whereas, if you take this Method, and will drink *Pymont*, or any other *Chalybeat* Waters leisurely, *viz.* a Pint-Glass in an Hour, or rather two Half-Pint Glasses, you may drink three Pints in so many Hours without Danger of losing them by Dejection. But if any one will be careful, and take this Caution with him, he will scarce fail of Success; that is, let him be very quiet and still, both in Body and Mind; the less he stirs or walks, the better he will pass off his Waters by Urine. And tho' this will appear a Paradox, especially to those Physicians who practise abroad, and commend to their Patients much Action in walking, yet I know I have both Reason and Experience on my Side. To avoid Prolixity I shall not declare them at this Time, and shall only ask leave to mention one Observation I have made, that none of our *English Steel* Waters do strike such a Purple as the Foreign celebrated *Chalybeat* Waters do for ours do give a more turbid and dark Colour, and the worse the Waters are, the blacker Sediment they make: Those of *Islington* abound with a coarse *Oker*, the Mineral is not well dissolved; but gives an *atramentarious* Colour; but the *Pymont* Waters excell all I have happened to examine, in its bright *Carulious* Lustre.

N. B. Most of the Experiments alleg'd by Dr. Slare, in the foregoing Discourse, were likewise by him shewn before the  
Royal

Royal Society, Feb. 28. last: and it was found that the Pyrmont Waters gave a much brighter Tincture with Galls and Tea, and had a much more exalted Chalybeat Taste than the Spaw; and a small Quantity of each being kept for some time in Bottles, to compare them, the Pyrmont was found to have retained its Virtues much better than the Spaw. The President, and several of the Members present, having drunk a Glass of it, found it of a very agreeable Relish, and to sit easie on the Stomach.

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IV. Remarks on the second Paper in the History of the Royal Academy of Sciences, for the Year 1711. concerning the Cause of the Variation of the Barometer: to shew that the Way of accounting for it in that Paper is insufficient, and that the Experiment made use of to prove what is there asserted, does no way prove it. By J. T. Desaguliers, M. A. F. R. S.

*The Paper is as follows.*

‘ **I**T appears by the Barometer, that when it rains,  
 ‘ or a little before Rain, the Air commonly be-  
 ‘ comes lighter.  
 ‘ That it must rain when the Air becomes lighter it  
 ‘ is easie to imagine; for the imperceivable Particles of  
 ‘ Water, that swim about in the Air in prodigious  
 ‘ Quantity, not being sufficiently sustain’d when the  
 ‘ Air has lost a certain Degree of its Weight, begin to  
 ‘ fall, and several of them joining together in the Fall,  
 ‘ make Drops of Rain. So when about half of the  
 ‘ Air is drawn out of the Recipient of the Air-Pump,  
 ‘ (and



‘ (and consequently the remaining Air is as weak again  
 ‘ as at first) something like a small Rain falls. But  
 ‘ why shou’d the Air become lighter? One might ima-  
 ‘ gine that in the Place where it rains, it may have lost  
 ‘ some of its Weight and Bulk, by means of the Winds  
 ‘ carrying away some Part of it. but Monsieur *Leibnitz*,  
 ‘ in a Letter to the Abbot *Bignon*, gives a more inge-  
 ‘ nious and more new Reason for it.

‘ He pretends that a Body, which is in a Liquid,  
 ‘ weighs with that Liquid, and makes up part of its  
 ‘ whole Weight, so long as it is sustain’d in it; but if  
 ‘ it ceases to be sustain’d, and consequently falls, its  
 ‘ Weight no longer makes a Part of the Weight of the  
 ‘ Liquid, which thereby comes to weigh less. This  
 ‘ may naturally be applied to the abovementioned Par-  
 ‘ ticles of Water; they encrease the Weight of the Air  
 ‘ when it sustains them, which is diminished when it lets  
 ‘ them fall: and as it may often happen that the Parti-  
 ‘ cles of Water that are highest, fall a considerable time  
 ‘ before they join with those that are low, the Gravity  
 ‘ of the Air diminishes before it rains, and the Barome-  
 ‘ ter shews it.

‘ This new Principle of Monsieur *Leibnitz* is surpri-  
 ‘ zing. For must not a strange Body, whether sustain-  
 ‘ ed in a Liquid or not, always weigh? Can it gravi-  
 ‘ tate upon any other bottom than that which sustains  
 ‘ the whole Liquor? Does that Bottom cease to car-  
 ‘ ry a strange Body, because it falls? And is not that  
 ‘ Body all the while it is falling, part of the said Li-  
 ‘ quid as to the Weight? At that rate, whilst a Chy-  
 ‘ mical Precipitation is made, the whole Matter ought  
 ‘ to weigh less, which has never been observed, and  
 ‘ scarce appears credible.

‘ Notwithstanding these Objections the Principle  
 ‘ holds good, when more closely examin’d. What su-  
 ‘ stains

' sustains a heavy Body is press'd by it. A Table, for  
 ' Example, which sustains a Pound Weight of Iron, is  
 ' pressed by it, and is so only because it sustains the  
 ' whole Action and Effect of the Cause of Gravity,  
 ' (whatever it be) to push that Lump of Iron lower.  
 ' If the Table should yield to the Action of that Cause  
 ' of the Weight (or Gravity) it would not be press'd,  
 ' and therefore would carry nothing. After the same  
 ' manner the Bottom of a Vessel, which contains a  
 ' Liquid, opposes it self to all the Action of the Cause of  
 ' Gravity against the said Liquid: If a strange Body swims  
 ' in it, the bottom opposes it self also to the said Action  
 ' against that Body, which, being in *Æquilibrio* with the  
 ' Liquid, is in that respect really a Part of it. Thus the  
 ' Bottom is press'd both by the Liquid and the strange  
 ' Body, and sustains them both. But if the Body falls,  
 ' it yields to the Action of Gravity, and consequently  
 ' the Bottom does no longer sustain it; neither will it  
 ' sustain it, till the said Body is come down to the  
 ' Bottom. Therefore during the whole Time of the  
 ' Fall, the Bottom is eas'd of the Weight of that Bo-  
 ' dy, which is no longer sustain'd by any thing, but  
 ' push'd down by the Cause of Gravity, to which no-  
 ' thing hinders it from yielding.

' Monsieur *Leibnitz* to confirm his Notion, proposed  
 ' an Experiment. He says, that two Bodies must be  
 ' tied to the two Ends of a Thread, the one heavier,  
 ' and the other lighter than Water, yet such as both  
 ' together may swim in Water: Put them into a Tube  
 ' full of Water, the Tube being tied to one End of  
 ' the Beam of a Ballance whose other End has a con-  
 ' trepoising Weight: Then if we cut the Thread which  
 ' ties the Bodies together (that are of unequal Weight)  
 ' so that the heaviest may presently descend. He says, that  
 ' in such a Case the Tube would be no longer in *Æqui-*  
 ' *brio*, but its counterpoising Weight would preponde-  
 rate

rate, because the Bottom of the Tube would be less press'd. It is plain, that the Tube must be sufficiently long, that the falling Body may not reach the bottom before the Tube has time to rise. In Chymical Precipitations, the Vessels are either too short, or what is precipitated falls sometimes too fast and sometimes too slow; for then the little Bodies are always (as to Sense) *in Æquilibrio* with the Liquor that contains them.

‘ Monsieur *Ramazzini*, the famous Professor at *Padua*, to whom Monsieur *Leibnitz* had proposed his Experiment, has made it with Success, after some fruitless Trials. Monsieur *Reaumur* (to whom the Academy had recommended it) has also made it with Success: This is a new View in Natural Philosophy, which, tho’ it depends upon a well known Principle, is very subtle and far-fetch’d; and gives us just Reason to fear that in Subjects that seem to be exhausted, several things may yet escape us.

### *Remarks upon Monsieur Leibnitz's New Principle.*

#### *Figure 4.*

LET  $AB$  be the Bottom of a Vessel full of any Fluid, whose Top is either wider than the Bottom as  $GH$ , narrower as  $EF$ , or equal to it as  $CD$ . The Pressure of the Fluid upon the Base  $AB$  will be equal to the Weight of  $CB$ , or of a Cylinder or Prism of the same Fluid, made up of the Area of the Base multiplied into the perpendicular Height above it.

If the Fluid be equally dense every way as Water, or of a Density uniformly diminish'd as you go upwards, this Proposition (call'd by Mr. *Boyle* the Hydrostatical

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Paradox) will hold good. This is demonstrated by all Hydrostatical Writers.

*Figure 5.*

Let  $EF$  represent part of the Surface of the Earth, and  $GEFH$  a Pillar of the Atmosphere, whose Height is  $GE$  the whole Height of the Air. Let us imagine the Vapours rising out of the Earth to form themselves into two Clouds  $A$  and  $B$ , and to settle in that Place where the Air is of the same specific Gravity with themselves. It is evident that they will cause the Air to rise so much higher as their Bulk amounts to, and will therefore make the Surface which was at  $GH$  to rise up to  $IK$ , so that the bottom  $EF$  which was press'd by a Pillar of Air as  $GEFH$ , is now press'd by an higher Pillar as  $IEFK$ . Now if the Clouds  $A, B$ , by any Cause soever, change their Place, so as to come downwards, (for *Exemple* to  $C, D$ ) the Height of the Pillar  $IEFK$  will remain the same as it was, and therefore the Bottom  $EF$  will be press'd as before: by the foregoing Proposition.

*Corollary I.*

If the Clouds  $A, B$  descend, and in their Descent keep the same Bulk as they had before, the Surface  $IK$  will remain the same, and therefore  $EF$  will be press'd as before.

*Corollary II.*

Whether a Body be specifically lighter or specifically heavier than a Fluid; so long as it is detain'd in it, it will add to the Fluid as much Weight as the Weight of an equal Bulk of that Fluid: wherefore a Body does not lose all that Weight which it added to the whole  
Weight

Weight of the Fluid, when it ceases to be sustain'd in the said Fluid: contrary to Monsieur *Leibnitz's* Principle.

*Scholium.*

If a Cloud (by any Cause whatsoever) becomes specifically heavier than that Part of the Air in which it swims, the Excess of its Gravity above an equal Bulk of Air will make it descend, and accelerate its Motion downwards; and then indeed it will lose of its Weight by the Resistance of the *Medium*, till it comes to an uniform (or sensibly uniform) Motion: but all the Weight that it will lose will only be the Excess of its Gravity above that of the Air; for with the rest of its Weight it will still make up part of the Weight of the Air.

*Experiment I. Figure 6.*

Having with a Weight in the Scale *C* of the Balance *AB* counterpois'd the long Glass of Water *EI*, with a Horse-Hair I let down the leaden Weight *W* into the Water, which from *FG* arose up to *EH*; and therefore the Water became heavier by the Weight of a Bulk of Water equal to the Lead. Having with another Weight in *C* made up the Counterpoise to the whole, with fine Scissars I cut the Thread of the Plummets; and all the while the Plummets was falling, the Water descended rather than rose; and when the Lead was at the bottom the Water overpois'd, because it had then added to it all the Excess of Weight of the Lead above an equal Bulk of Water, which by Experiment is about  $\frac{1}{11}$  of its Weight. Had Messieurs *Reaumur* and *Ramazzini* tri'd the Experiment thus, the Success had been the same; but Mr. *Ramazzini* (as I understood from a Gentleman who was present) tried it in the following Manner, as I have since done.

T t t t z

Ex-

*Experiment II. Figure 7.*

Making use of the abovemention'd Machine, after I had balanc'd the Water and Lead in it, I fix'd to the End of the Beam *B* the Thread of the Plummer, which in the former Experiment I held in my Hand. This added to the Weight hanging at *B*, and oblig'd me to put into the other Scale a Weight equal to  $\frac{2}{3}$  of the Lead, to recover the *Æquilibrium*. Then cutting the Thread or Hair, the Scale with the Weights overpois'd whilst the Lead was falling; but the *Æquilibrium* was restor'd when it came to the Bottom. So that the Lead even then must have lost only its Excess of Weight above Water.

*Experiment III. Figure 8.*

I tried the Way propos'd by Monsieur *Leibnitz* in the following Manner.

I took a Cork *C* weighing an Ounce, and something more than four times lighter than an equal Bulk of Water, and a Ball of Antimony *W* about four times specifically heavier than Water, and of four Ounces Weight. The Cork laid upon the Water in the Vessel *EABD* rais'd the Water from *SS* to *GG*, and added an Ounce to the Weight of the whole Water: then suspending the Ball of Antimony by a String, and letting it hang in the Water at *N*, it rais'd the Water from *GG* to *HH*, and so added another Ounce to the Weight of the Water. Then tying the Antimony to the Cork (See the Figure of the Vessel mark'd with little Letters) the Cork had added to it three Quarters of the Weight of the Antimony which the Hand before had sustain'd, and made it sink so as to be almost cover'd, and rais'd the Water to *ik*, adding three Ounces to its Weight. Hanging this Vessel of Water upon the Balance, and a Coun-

Counterpoise at the other End, upon cutting the String the Vessel of Water was rais'd up, and the *Æquilibrium* was not restor'd till the Antimony came to the Bottom.

By observing that as the Cork (being freed from the Weight of the Antimony) arose, and that during the Fall of the Body, the Water sunk to *h h*, it appears that this is, in effect, the same Experiment as the former, and concludes no more. As to the real Cause of the Variation of the Barometer, namely, the Accumulation of the Air by Winds over the Place where the Barometer rises; and part of the Air being blown away where the Mercury in the Barometer sinks. see Doctor *Halley's* Account of it in the *Phil. Transactions*. Numb. 181.

## POSTSCRIPT.

**I**N making the first Experiment before the R. Society, of a Piece of Lead suspended by a Thread, whilst it was wholly cover'd with Water in the large Tube in which it hung (whose Length was 4 Feet) it was observable, not only that the End of the Balance (to which the Tube of Water with the Lead in it was fixed) did not rise when the Thread was cut, (to let the Lead fall from the Top to the Bottom of the Tube) as it must have done according to Mr *Leibnitz's* Principle; but that the said End of the Balance began to descend from the Time that the Lead began to fall. Therefore to be sure that it was not the Plummet rubbing against the Sides of the Tube in its Fall, which caused that *baromenon*, I hung to the Balance a long Glass of three inches diameter instead of the Tube, and making the Experiment as before, it succeeded in the

the same manner : the End of the Balance which carried the Vessel of Water sunk as soon as the Thread of the Plummet was cut ; tho' this Glass was not above half so long as the Tube.

When by holding the String I drew the Lead upwards and downwards in the Water, there was no sensible Alteration of the *Æquilibrium*. Neither was it alter'd by cutting the String of a Stone-Plummet, because of the Shortness of the Glass, and the little Excess of specifick Gravity in the Stone : for the greater the Difference is betwixt the Body made use of in this Experiment and Water, as well as the bigger the Body it self is, the better the Experiment will succeed.

Hence it appears, that when a Body, specifically heavier than a Fluid, is (by what cause soever) detain'd in any Place of the said Fluid, it adds as much to the Weight of the whole Fluid as an equal Bulk of the said Fluid amounts to : And when the said Body, by the Action of its Excess of specifick Gravity above the Fluid, descends with an accelerated Motion ; so long as that Motion is accelerated, the Resistance of the Fluid (which is as the Square of the Velocity) takes off something of the whole Weight of the Body ; but as much as the Body loses, so much the Water gains, over and above what was given it by its rising on Account of the immers'd Body.

A Body therefore that falls in a Fluid is so far from making the Fluid lighter as it falls, that it makes it press more upon the Bottom that sustains it, when it is falling, than when it was at rest in the Fluid.

If the Vessel of Water be long enough for the falling Body to come to an uniform Motion before it reaches the bottom, the Force impress'd on the Water under the Body will make it press the Bottom, as much as if the Body were actually at bottom ; the Body in that Case losing



ing all its Excess of Gravity above that of the Water, and the Water gaining it.

Hence it follows, that a falling Cloud, when it comes to an uniform Motion, will not only add to the Weight of the Air as much as the Weight of an equal Bulk of Air; but even as much as its whole Weight amounts to, tho' it be specifically heavier than the Air about it.

All the Diminution of Weight that can be allow'd in this Case is this. If we imagine the Air to have a smooth, regular Surface, as we have at first suppos'd, (or if that be not allow'd, we may take any imaginary Surface of it above the Clouds) when a falling Cloud is diminish'd in Bulk, (as when it is chang'd into Rain) the Surface of the Air will subside in proportion to that diminution, and therefore will weigh less, by so much as is the Weight of a Quantity of Air equal to the Bulk that Cloud has lost: But when the Drops of Rain after their Acceleration (occasion'd by their Excess of Gravity above that of the Air) are come to an uniform Motion by the Resistance of the Air, they restore to the Air the Weight that it had lost. Now this uniform Motion being acquir'd in about two Seconds of Time, and the Diminution of Gravity in the Air being insensible, when compared to near three Inches of Mercury (for such is the Variation of the Barometer with us) can no way be the Occasion of those so sensible Alterations in it, which happen some time before Rain or Fair Weather.

*Add to this that the whole Quantity of Rain that falls in England and France, in the Space of one Year, scarce ever equals two Inches of Mercury: And in most Places between the Tropicks, the Rains fall, at certain Seasons, in very great Quantities, and yet the Barometer shews there very little or no Alteration.*

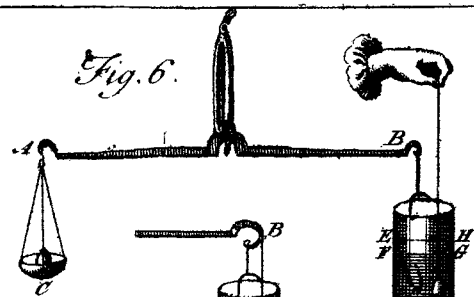


Fig. 6.

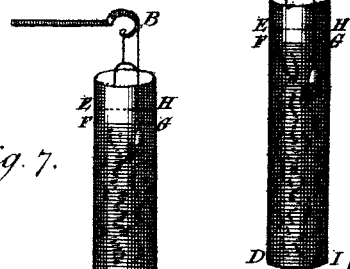


Fig. 7.

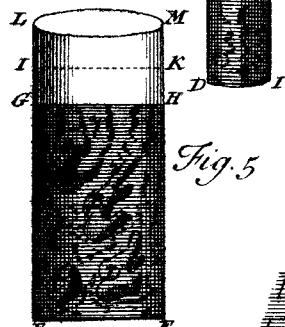


Fig. 8.

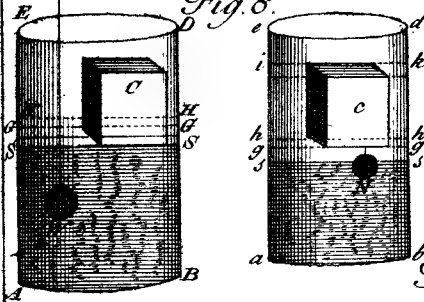


Fig. 9.

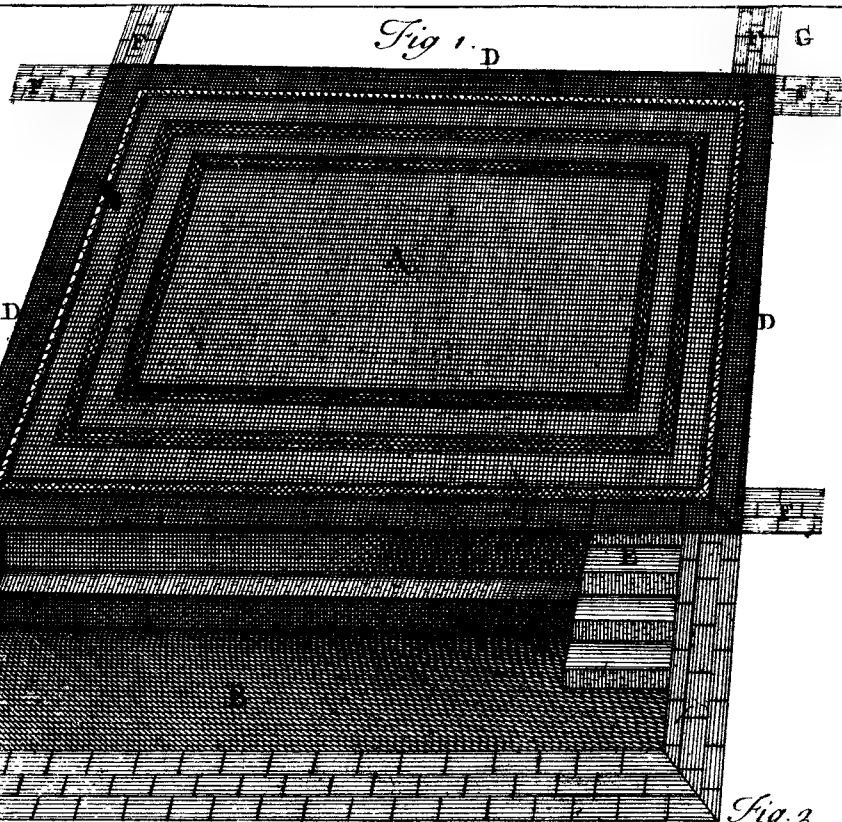


Fig. 1.

Fig. 2.



A The Pavement. B The Bath. C The Sink and the other Passage through the Wall at the East end of the Bath. D The Roman Brick w<sup>th</sup> bounded, the Pavement, laid flat and covered with Terras. E Foundations continu'd several ways. F The Landing place out of the Bath. G The corner of a large space paved w<sup>th</sup> Roman Brick, and cover'd with Asphes, Coals, &c.

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V. *An Account of an extraordinary Effect of the Cholick: communicated to the Royal Society, by that curious Anatomist Mr. St. Andre, and read March 21. 1717.*

THE *Peristaltick* Motion of the Intestins is by all Anatomists suppos'd the proper Motion of those Cylindrical Tubes.

The use of this Motion is to propel the Chyle into the *vasa lactea*, and to accelerate the grosser Parts of the Aliment downwards, in order to expel them, when all their nutritive Contents are extracted.

This Motion thus establish'd, it naturally seems to follow that an Inversion of it (call'd for that Reason an *Antiperistaltick* Motion) shou'd force the *Aliments*, *Bile*, *pancreatick Juice*, and lastly the *Feces* to ascend towards the Mouth.

The Cause of this imaginary *Antivermicular* Motion, is assign'd to a Stoppage of the Intestin, or to a great length of it being engaged in the same manner as the Fingers of a Glove are choak'd by inverting the Glove in drawing it off: Or like as a Silk-Stocking, which when 'tis not gartered, falls upon the Foot, and is in a manner strangled, so that some Force is required to bring it up again.

This suppos'd, the *Antiperistaltick Hypothesis* seems at first Sight very natural, and answers most Difficulties. For if the *Vermicular* Motion accelerates the Contents of the Intestins downwards; the *Antivermicular*, by the Law of Contraries, should force them upwards towards the Mouth.

Was

Was this Supposition as certain as 'tis generally receiv'd, I shou'd not presume to advance that there is no such thing as an *Antiperistaltick* Motion of the Intestins; nor that the *Miserere mei* is oftner a violent Contraction of the Abdominal Muscles, than a Stoppage or Inversion of the Intestins, as 'tis suppos'd.

So laying aside all Prevention, let it be granted that this Disease is a violent Contraction of the Abdominal Muscles, as I have already suppos'd it, caus'd by the Redundancy of the Intestins or their Contents. Then comparing the Symptoms of this Disease, with those of the different Kinds of *Hernias*, we shall find by the Analogy of the Parts, Reason and repeated Experience, that the *Chordapsus*, so call'd by *Celsus*, is a Disease in which the Intestins and *Omentum*; at other Times the *Pancreas* or *Spleen*; nay, even the *Mesentery* it self are forc'd through the *Diaphragma* into the *Thorax*.

All these tender Parts being strongly compress'd, by the continual Motion of this Muscle, must by consequence cause the same Accidents as in the *Bubonocoele* or compleat *Hernia*, there being no difference in these two Cases; but that the first is a strangling of the *Intestin* by the *Diaphragm*, and the latter a choaking of the *Intestins* by the *Abdominal Muscles*.

One Example of the many of the like Nature, that I can produce, will much confirm this Assertion, and may serve to convince any Person that is impartial.

The Case is this: A Gentleman that came to Town yesterday was Sevennight in good Health, meeting with some Friends, drank a great deal of new bottled Oat-Ale, after some Pints of Wine. These Liquors fermented so violently in his Stomach and Intestins; that he was taken with a violent *Cholick* the same Night.

In the morning an Apothecary was sent for, who administred a Clyster, and took some Ounces of Blood

to relieve the Patient, who complain'd of a great Pain in his left Side.

The Clysters being repeated the Night following, as also the next Morning, and the Patient growing worse; the Apothecary, without Order of any Physician, gave him a violent Vomit; which operated Eight or Nine Times: This added Fuel to the Fire; and the Patient having from that Time been in a desperate Condition, two eminent Physicians were call'd, who order'd that the Clysters shou'd be repeated: But they not prevailing, I was sent for about six Hours before the Patient died: I found him complaining of a violent Pain in all the Region of the *Abdomen*; a frequent Inclination to vomit; having a great Difficulty of breathing, together with a very slow Pulse; his Belly being as hard as a Stone, tho' not swell'd.

This last Indication made me conclude, that the Disease was a violent Contraction of the Abdominal Muscles, which had overcome the *Diaphragm*, and that probably the *Intestines* might be forc'd into the *Thorax*.

I was the more confirm'd in this Opinion from the Examples of the like Case, which I shall shortly lay before the Society; upon which I order'd a Fomentation of hot Milk, adding to every Quart a Drachm of *Liquid Laudanum*, which in these Maladies gives great Relief: But before it cou'd be got ready, the Patient expir'd in a violent Convulsion.

My Opinion having been highly censur'd by the two Physicians; I open'd this Gentleman, to justify my self, or to own my Fault openly, if I had been mistaken: But as the thing happen'd as I conjectured, those Gentlemen will forgive me for taking the Liberty of justifying my self.

In opening this Body, I found the Abdominal Muscles so much contracted, that it was almost impossible to penetrate them with a very sharp Scalpel. Upon

Upon Examination, I found the Stomach empty, and some Parts of the *Duodenum*, but the *Jejunum* and *Ilium* so much distended with the fermented Oat-Ale, that the *Ilium* had four Inches of Diameter, and the *Colon* above eight.

The *Ilium* was also pretty much inflam'd in its inferior Part; and all the Valves of the *Colon* were obliterated, by the great Distention of that *Intestin*.

But the greatest Disaster was, the Dilatation made in the *Diaphragm*, as I suppos'd; made just upon the Chink which remits the intercostal Nerve to the *Viscera* of the *Abdomen*, through which a Portion of the *Colon* was forc'd, and the greatest Part of the *Omentum* and *Pancreas*.

These tender Parts being choak'd, soon inflam'd, a Mortification of them following; and a Rupture of the *Pancreatick Vein* caus'd an internal *Hæmorrhage*, which fill'd all the left Cavity of the *Thorax*, insomuch that the whole left lobe of the Lungs was compress'd almost under the *Musculus Scalenus*.

The Quantity of extravas'd Blood was very great, and it was not in the least coagulated.

I have brought the diseas'd Parts with me, to shew the Society the Certainty of this Account, and I shou'd have been more particular in proving the Impossibility of the *Antiperistaltick* Motion; if Doctor *Hagumot* had not prevented me by his *Memoir*.

This Gentleman is not far from Truth, and what he says is certain: but I am surpriz'd that the like Case has not occur'd in his Practice.

VI. *An Account of Two late Northern Aurora's, as they were observ'd at the Vicarage of Sutton at Hone in Kent. By the Reverend Edmund Barrell, Prebend of Rochester:*

ON February the 5th 171 $\frac{1}{2}$ . at Eight at Night. an *Aurora Borealis* appeared. It occupied at least  $\frac{1}{2}$  or near  $\frac{1}{2}$  of the Horizon; it was low, and shot out bright Rays, and, I believe, would have appeared very light, had it not been that the Moon shone at the same time, being about Five Days old, and that the *Aurora* disappear'd before the Moon set.

Again, on the 30th of *March* following, there was another *Aurora Borealis*. I saw it not till past Nine: 'twas dim then, and its highest Part cover'd the lowest Star in *Cassiopea's Chair*. It did not seem due *North*, but one Point to the *West*. About Ten it shot out very bright Rays, high, and tending somewhat towards one another. Near Eleven a Clock, there was (besides the *Northern Brightness*) a long Streak, not very broad, extended *East* and *West*: Which beginning in the *Serpent's-Head*, near *Hercules-Club*, and covering *Arcturus*, proceeded near *Berenices Hair*, and so went over *Cor Leonis*, and thence to the *Canicula*, and ended a little beyond that Star. It shone very bright at first, but faded away in about Eight or Nine Minutes. If it had Motion (which I am not sure of) it was Southward. I waited for the next Fit of Brightness of the *Aurora*; and in about Seven Minutes, the *Eastern Part* of the Streak, *viz.* from the *Serpent's-Head* to near *Berenices Hair*, became visible again tho' dim. and was quite effaced in Four or Five Minutes more: And I did not yet perceive any Change of its Place.

F I N I S.

Errata. Page 556. in the Note, lege *Lib. xxxv.* pag. 563.  
line antepenult. lege *Anderida*.

L O N D O N, Printed for W. Innys, at the Princes Arms in  
St. Paul's-Church-Yard, 1717.

# PHILOSOPHICAL TRANSACTIONS.

For the Months of *April, May, and June, 1717.*

- I. *An Account of the Aurora Borealis, seen at London, on the 30th of March last, as it was curiously observ'd by Martin Folkes, Esq; R. S. Soc.*
- II. *Guilhelmi Musgrave Regie Societatis Socii, de Britannia quondam Pæne-Insula, DISSERTATIO.*
- III. *Extracts from Mr. Gascoigne's and Mr. Crabtree's Letters, proving Mr. Gascoigne to have been the Inventor of the Telescopick Sights of Mathematical Instruments, and not the French. By W. Derham, Prebend of Windsor, and R. Soc. Soc.*
- IV. *An Attempt towards the Improvement of the Method of approximating, in the Extraction of the Roots of Equations in Numbers. By Brook Taylor, Secretary to the Royal Society.*
- V. *Proprietates quædam simplices Sectionum Conicarum ex natura Focorum deductæ; cum Theoremate generali de Viribus Centripetis; quorum ope Lex Virium Centripetarum ad Focos Sectionum tendentium, Velocitates Corporum in illis revolvantium, & Descriptio Orbium facillime determinantur. Per Abr. de Moivre. R. S. Soc.*



I. *An Account of the Aurora Borealis, seen at London, on the 30th of March last, as it was curiously Observ'd by Martin Folkes, Esq; R. S. Soc.*

**B**Eing in the Street, between 8 and 9 a Clock on Saturday last, (30 Martii) I perceiv'd a Light over the Houses to the Northwards, little inferiour to that the Full Moon gives when she first rises. Upon this, suspecting some such Meteor as we saw the last Year, I made all the hast I could into the Fields, where I immediately found my Conjecture verified; and was for some time agreeably entertain'd with the sight of an *Aurora Borealis*, attended with most of the *Phænomena* that have been describ'd in that very remarkable one of the 6th of March, 1715-6.

The whole Northern-Part of the Horizon was in the same manner cover'd with somewhat resembling a very considerable Light, whose lower part was pretty well defin'd by the common Edge of the Cloud, but the upper dy'd away more gradually. This upper Limb of the Light resembling the Arch of a Circle, whose highest Point between 9 and 10 of the Clock (when the Meteor was most considerable) was elevated about 12 Degrees, and bore, as I imagin'd about 20 deg. Westward of the due North. It touch'd the Horizon in the West at the distance of about 65 or 70 Degrees from the North, whence the whole intercepted Arc of the Horizon would have been of near 100 Deg. had not some few Degrees in the East been hid by Clouds which lay between us and the Meteor.

The seeming black Cloud when I first saw it, ran nearly parallel to the Horizon, and at the distance of 6 or 7 Degrees: but in about half an Hour it changed its Figure  
very

very much, sinking down in the North to about half its height, and rising in the West near as much. What I principally took notice of this for, was that the Light issuing from behind it did not change with it, but remain'd of the same Figure, however the Cloud approached or receded from differing Parts of its Limb.

There arose at first some Streams in the *N. N. W.* but of no considerable Length, few of them passing 5 Degrees above the Arch; but beginning from behind the seeming Cloud, so as to be about 12 Degrees high in all. They were Pointed at the Ends, and nearly vertical to the Horizon. Between times there was nothing but the Arch to be seen, and that only resembling a common *Aurora*; and again in an instant, by a sort of tremulous Motion, several Parts of it would appear converted into a vast number of parallel Streams, for the most part very little higher than the Arch it self. About 20 Minutes before Ten, a small part of the Arch almost due North, grew remarkably lighter than the rest, and continued to encrease for about half a Minute; when there suddenly broke out some very tall Streams of at least 60 Degrees high, as I found by one in particular which arose full North, and passing over the Pole star it self, reach'd some Degrees beyond it. This was the most remarkable time of the Appearance, some such Lances, though not so high, immediately shooting out of the Place that first of all radiated, as did some more a good way to the East. They were all nearly Perpendicular to the Horizon, and most of them did arise quite from the black Substance at Bottom, tho' I saw some few that did not reach so low, appearing as if their lower Parts had been broken off. Some of them were full as bright as any I saw the last Year, the Axes (if I may so call them) of some of the tallest Streams coming up very  
near

near to the Colour of that pale Fire we see in some sorts of Lightning.

About this time the Ground Westward was all cover'd with an odd sort of Mist, the same from which I remember last Year a great many People said there came an ill smell, which I did not at all perceive; however as I remember it to be the very same Appearance, I thought it might not be improper just to take notice of it.

About 10 the *Phenomenon* very much decreas'd, and so continued till after 11, only sending up now and then 2 or 3 Streams. At half an Hour after 11 it was again pretty much encreas'd, and I saw it again send out some Streams almost as considerable as any I had before seen this Evening; the Arch yet continued, but not so entire; and from what I could judge, its middle was some Degrees nearer the North than when I first took notice of it. Till a quarter of an Hour before 12 the light continually abated, and then I left it; but a Watchman, I order'd to bring me an Account of it next Morning, tells me it continued till towards Day-break, but never stream'd remarkably after I went away.

Tho' I could not this time see any Stars through the black Matter at Bottom, I am sensible it was not a Cloud, tho' it bore the resemblance of one: for when a real Cloud (as several small ones did) came over any part of it, their difference was very conspicuous.

I have since receiv'd two Letters, one from *Witch* in the Isle of *Ely*, the other from within 14 Miles of the *Bath*, both which take notice of it, tho' with no further Particulars, than that on *Saturday* Night, they had seen the same Light, tho' not so considerable, as in the beginning of *March* the last Year.

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## II. Guilhelmi Musgrave Regiæ Societatis Socii, de Britannia quondam pæne Insula, DISSE- R-TATIO.

CUM *Belgium* nostrum a *Britannico* adluitur O-  
ceano, illo latere *Insulæ* hujus triquetrx, quod est  
ex adverso *Gallia*; visum mihi fuit, priusquam id de-  
scribere conarer, antiquam & diu agitatam movere quæ-  
stionem, de *Britannia* cum *Gallia* conjunctione, &, an  
revera unquam esset, exquirere.

PRIMUM igitur, posita *Chersoneso Britannica*,  
utrum exedi potuerit: Deinde, utrum exesa fuerit, edifi-  
ceram.

DE priori propterea dicendum, quod a docto &  
magni nominis Viro, *Vossiorum* altero, strenue negatum  
sit, unquam, ubi hodie Fretum est, fuisse *Chersonesum*:  
& quidem ideo negatum, quoniam, illo sentiente, nihil  
ei deterendæ dividendæque par inveniatur. Ut *Tapro-*  
*banam* (*Insulam Ceylon*) a vicina continente non avelli  
probet Vir Clariss. [*Otio* (a), inquit, abundant, qui istius-  
modi *Ægyptiorum* fabellis, jam millies productis, totiesq; reco-  
ctis, aurem commodant. Quam constans & tenoris sui ob-  
servans sit rerum natura, patet e *Bosporis*, omnibusque omni-  
um terrarum Fretis. Iis cum præcipue *Marium* & ipsius  
Oceani vis semper incubuerit, eadem tamen ubique a tot an-  
norum millibus & ab ipso, ut verisimile est, rerum exordio,  
servaret intervalla. Currant licet, ac recurrant *Undæ*, al-  
latrent undequaque *Fluctus*, fortius est Elementum quod re-

---

(a) In Notis ad *McLam*.

*sistit, quam quod oppugnat. Exesi Scopuli, ac vasta maris antra, satis ubique ostendunt, quantum Oceani impetus lapsu seculorum possit efficere: verum hæc ipsa quoque, quid non possit efficere Oceanus, multo clarius ostendunt.]*

*Hæc Isaacus.*

UT disputationem ea de re ingrediar, Vir hic Clariss. Naturæ, nec qua agit illa nec qua patitur, statum ac conditionem, ex omni parte, sic, ut est revera, animo satis advertisse videtur. Cum non de *Taprobana* solum Freto commentatur, sed de Fretis in universum, & quidem Argumento a *constante & tenoris sui observante rerum natura* accepto, videamus quam hæc cum Oceanis & Freto nostris conveniant, & in iis quam constanter agat Natura.

OCEANI *Britannici*, prout nunc dierum est, cum latitudo tum profunditas investiganda, ut ex iis de prisco seu Freto, sive Sinu, possimus sententiam ferre. Ut autem eas comperiamus, adeunda est Tabula *Halleiana*, sui generis omnium accuratissima, ex jussu Regis *Guilhelmi* ejus nominis Tertii constructa. Ea docemur, in Oceano *Britannico*, ubi Terrarum hiatus, hac illac amplissimus est, a veterum *Ocrino* (*Lizard-Point*) ad Insulam ei oppositam *Ushant*, unum esse gradum cum semisse, id est Leucas quasi triginta, sive milliaria 90. Hinc Oceanus se in oriente parum adducit, at multo magis ubi Promontorium in eum procurrit *Normanicum*: ibi enim est dimidio adductior; cum inter *Peverel-Point*, & *Cap. de Hague* e regione sita, Leucarum *Anglicarum* quasi 16 distantia sit. Tunc se iterum effundit, ubi *Sequanam* recipit: at brevi in arctum agitur, inter *Beachy-Head* & *Cape St. Vallery*. Dein paulatim angustior, fastigiat se molliter, usque dum in Fretum contrahitur, inter *Nefs Anglorum*, & *Gallorum Blackness*, non amplius octo Leucis, id est 24 milliaribus patens. Terræ  
tunc

tunc aperiuntur longe lateque vastissime, & spatium Mari faciunt *Germanico*.

HÆ sunt Oceani Fretique *Britannici* diversæ latitudines; quibus apparet, eas, si non continuo, tamen adeo rara tamque exigua cum ampliacione minui, ut argumento nostro nihil inde queat derogari. Ita enim Oceanus contrahitur, ut qui initio, seu Faucibus ejus *Britannicis*, Leucas triginta, sive Milliaria præterpropter nonaginta latus sit, post Leucas 153 circiter, sive Milliaria 460, (quæ hujus Oceani longitudo est) ad 24 milliaria contrahatur; id est ad primæ latitudinis partem quasi quartam.

PROFUNDA hujus Oceani altero jam loco sunt expiscanda, & quidem optime beneficio ejusdem Tabulæ. In ea dividitur Oceanus *Britannicus* una cum Fretto, in Columellas numero decem, oblongas. Harum singulæ latera sunt ex circulis Meridianis accepta; quæ cum in plano ducta sint, videntur esse recta. Columellæ terminantur adversis *Galliæ Britannique* litoribus: hoc est, Lineis huc illuc curvatis in litorum morem.

INCIPIAMUS a prima in occidente, quæ & longissima Columella est: & (præmisso, quod *Hiberniam* & *Galliam* inter, Oceanus orgyias altus sit in locis compluribus octoginta; uti paulo ulterius in aperto Mari, 100, 120, 140) notandæ sunt in prima Columella profunditates omnium altissimæ; quæ decies exploratæ se habent, ut 58, 66, 63, 65, 58, 65, 68, 60, 60, 60. quæ profunditatum Summæ faciunt 623 orgyias. Ex per decem, i. e. profunditatum numerum, divisæ, mediam earum profunditatem ostendunt esse 62.

IN Columella altera, decem altissimarum media profunditas, simili modo investigata, est orgyiæ 51. In tertia 51. In quarta 40. In quinta 43. In sexta 40. In septima 36. In octava 37. In nona 33. Post nonam Columellam, cum Oceanus in lævam flectitur, &

obliquus in Fretum desinit, accipiam illud ut Terris interjacet, in *Britannia* locis appellatis *South-Foreland* & *Hastings*, in *Gallia* *St. Valery* & *Estaples* inclusum. Hic profunditatum decem media est 30. In Freto angustissimo 16: quæ ad profunditatem mediam in prima Columella, est, ut 16 ad 62; id est, ut 1 ad 4 fere; & ad altissimam profunditatem *Galliam* inter *Hiberniamque*, ut 16 ad 80, i. e. ut 1 ad 5: ad altissimam in aperto Mari, ut 16 ad 140; i. e. ut 1 ad 9 fere

QUA proportionem minuitur altitudo Maris, ea crescit Terræ Mari subjæctæ acclivitas; & est illi in *ratione inversa*: quæ utique propositio, si non ex omni parte vera, (propter orbis figuram minime rotundam) tamen adeo veræ proxima est, ut argumentationi nostræ sufficiat. Est ergo Terra, in Freto nostro angustissimo undis subjæcta, quam in Oceani *Britannici* faucibus, orgyias 46, id est pedes 276 altior; & quam Terra, *Galliam Hiberniamque* inter, Oceano subjæcta, orgyias 64, sive pedes 384 altior; & quam Terra, aperto Mari subjæcta, 124 orgyias, sive pedes 744 altior. Vide quanra sit Terræ ab alto Mari ad Fretum acclivitas; eaque ut ex calculo prædicto patet, fere continua. Hæc est Oceani *Britannici*, tam in illius Latitudine, quam Profunditate contractio.

AG E, nunc tendamus ultra, velis expansis, in Oceanum *Germanicum*: Hic Mare subito patentius, sic. ut etiam profundius: quod inter Promontoria *North-foreland*, *Orfordness*, Oppida *Caletum* & *Ostendam* interfluit, decem maximas habet mensuras, quarum media 24 Orgyias cum  $\frac{1}{2}$  continet: quod inter *Orfordness*, & *Tarmouth*, *Texellam* & *Ostendam* est, maximas decem mensuras habet, quarum media 25 Orgyias cum  $\frac{1}{2}$ . Quicquid ultra est, Terris, hinc ad occidentem, illinc ad orientem se retrahentibus, vastissimus est Oceanus, in quo mensuræ sunt ab orgyis 45 ad 50 numero quamplurimæ.

HÆC

HÆC a Freto *Britannico* tam in oriente, quam occidente Terræ declivitas (quæ a Maris altitudine utrobique aucta patefit) omnino probat, *in ipso Freto jugum esse Terræ excelsum, acutum*; quod cum hodie non multum infra Maris superficiem esse reperiatur, olim se emergere, hoc est *Cherronesum olim hic fuisse, monstrat.*

ALIA sunt duo, quæ cum in hac re momenti sint immensi, tenore tum minus certo, & natura minus sunt constanti; quandoquidem a Maris motu & ventis accepta. In refluxu Maris Aquæ nunc quiescentes incubant arenæ; nunc eam molliter præterlabuntur. In æstu mitiori, Lirus & ima Rupium blandissime lambunt, tenerrime osculantur. Fervente vero æstu, res omnino alia est: Aquarum Fremitus auditur, Fluctus cernuntur, & se non parum attollunt. Nihilominus sine multa strage, terrisve aliquot annorum millibus exesis, hæc omnia posse fieri, cum *Vossio*, cogitandum est.

SIN æstuant Mari, quod altero loco dicendum est, Ventus superveniat (*Flat autem Ventus sic, ut vult, & quis ei tempus statuerit, aut modum imposuerit?*) papæ! quoti, quantique Fluctus advolvuntur! *Alpes* existimare licet Crystallinos, nisi quod cito diffuant. Montem enim Mons invadit, detrudit, discutit; tantisper ejus spoliis adauctus, dum in cælum altissimus exurgit Aquæ Mons. Tanta vis Aquarum ex Oceano occidentali in *Britannicum* immittetur, & tanto imperu, quantus in universo Terrarum orbe rarus invenitur; imo quantus ab ipso rerum initio rarissime. Oceani *Britannici* tum brevia, tum angustię, continuo pœne (quod ostensum est) crescentes, faciunt, ut Aquæ sic impulsæ mirum in modum eleventur, & in Isthmum (quem argumenti gratia fuisse damus) arietent, ita ut ab iis Isthmum exundari, deteri, ablui; sicque Insulam fieri *Britanniam* non videatur *ἀδυνάτων ἐν*; verum e contrario factu probabile. Quantæ Ventorum, at præcipue



Zephyri Cauriq; virtutes sint, in cogendo impellendoq; hoc Oceano *Britannico*, paucis expendam, a Doctissimo viro *Rad. Bohun*, (*Nevi olim Collegii Socio*, qui *de Ventis* omnium eruditissime scripsit) hac in re adjutus.

ETIAM SI Zephyrus a Poetis *vitam rebus ferre* dicatur.

——— *ejusque tepentibus auris*

*Laxent Arva Sinus; ———*

interdum ita fit, ut

——— *Eurique Zephyrique tonet domus; & ut*

——— *Zephyro multa turbentur arena.*

Adeo sævus, horribilis, iracundus sæpe Zephyrus, Vires in Oceano, qui *Europam & Americam* vastus interjacet, acquirens, & in amplissimo hocce campo recensens, vix concipi potest, quanto *Britannia Gallique* oras impetu invadat. Exploratissimum enim est, in hæc oras eum communiter anni plus dimidio flare, (quod jam olim a *Julio Cæsare* notatum) & flatu eas sævissime verberare: maxime autumnus, a quo sumunt originem Tempestates Idiomate nostro dictæ [*Michaelmas-Storms*] eumq; adeo interdum sævire, ut si cum æstu fervente jungi Ventus hic acciderit, tam Oceanus *Britannicus*, quam Fretum *Sabrinianum* immane quantum augeantur. *Sabrina* vastissime turget. *Uzella* longe lateque *Somersetensem* Agrum exundat: Mirum ab hisce Cataclysmis quantum mea patria perpessa est. Continuatur æstus ad usque *Tewkesbury*, id est milliaria magis ducenta. Apud *Chepstow* Aqua pedes interdum octoginta assurgit. Idem fere dicendum de Oceano *Britannico*, Venti ejusdem viribus elato: nisi quod hic, *Chersoneso* jam effracta, liberius Aquæ moveantur, non adeo sistantur, non tantum eleventur; quæ utique Aquarum libertas ante *Chersonesum* abruptam, nequaquam adeo magna esse potuit.

HAC igitur de causa [*Zephyro* nempe, *Cauro*, sive alio Ventorum aliquo, Maris æstui superveniente] Oceani *Britannici* Undam in Isthmum validissime impingi, & ab illis primum ejus superficiem, quæ ex Silice & Calce (prout hodie Terræ e regione oppositæ) constabant, ablui; deinde Isthmi quod reliquum erat, spatio bis mille annorum & eo amplius, Aquæ fluxu refluxuq; ad 16 orgyias, quæ hodierna Freti hujus (quod diximus) altitudo est, atteri credibile, verisimile est,

TANTUM abest, ut *Vossio*, Fretorum perpetuitatem a naturæ in operibus suis *constantia* tenoreque eodem arguenti, fidem habeamus, ut e contrario Fretum hocce nostrum illius *inconstantia* deberi, lubens agnoscerem. Vir ille clarissimus, naturæ usitatum agendi modum unice respiciens, *extraordinarium prætermisit*; qui tamen, in raris hujusmodi effectis, potissime videtur respiciendus. In Freto *Siculo* considerando, ejusque diducendi modo investigando, quis Ignis subterranei supra modum erumpentis, tamquam Causæ hac in re probabilis, non meminerit? nisi istam *Catanensium ἀτομίαν* consecutus, qui (tradente *Alphonso* † *Borello*) post Eruptionem *Ætnæ* diu intermissam, Ignem ejus immodicum ne semel quidem unquam fuisse, satis insulse putavere. Ut Vento nihil inconstantius, sic ad Fretum hoc aperiendum (posito causarum apparatu cætero) nihil conducibilius: & cum eo res deducta est, *fortius elementum esse quod oppugnat, quam quod resistit*, (aliter quam *Vossius* statuit) omnino probabile mihi videtur. *Salmasium* ille, Virum & candidum & doctum convellit, quod de Navibus absque Costis & Interamentis, ita scripsit, ac si in *Burgundia* mansisset, nec quid rei Navis aut Mare foret, intellexisset. Nequeo satis *Isaacum* mirari, quod de *Mari* & *Ventis* scriptor luculentus, horum vires in Mari

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† In Libro de Incendiis *Ætnæ* p. 117.

turbando agitandoque, in terris obruendis abrumpendisque; prorsus omitteret; atque adeo quod *BATAVUS* omitteret: ca scil. Regione oriundus, quæ Mari & Vento tam obnoxia.

NON alienum erit hic Inundationum aliquot exempla, uti revera fuere, in medium proferre; quibus abunde patet, Terræ faciem frequenter obrui, & ab iis non parum mutari. Hic autem nihil necesse est, ut *Helicen* & *Burin*, *Achaia* Urbes adeamus: de quibus tamquam magnarum Inundationum argumentis, (1) *Ovidius*, & diu ante illum (2) *Aristoteles*. Gravissimas fuisse Oceani nostri, tam *Germanici* quam *Britannici*, satis ostendunt Historici Geographique.

IN *Zeelandia* (3) Insulæ undecem, & in iis Oppida & Pagi (quorum hodie summitates aliquæ, refluxu Maris in conspectum veniunt) numero ter centum (4) obruebantur.

ANNO 1014. [*Mare. Litus egreditur III. Cal. Octob. & in Anglia Villas quamplurimas innumerabilemque populi multitudinem summersit.*] (5) *Simeonis Dunelmensis* Historia de Gestis Regum *Anglorum*. De hac, ut opinor, Inundatione videatur etiam *Chronicon Joh. Brompton* (6).

ANNO 1099. [*Tertio Non. Novemb. mare Litus egreditur, & villas & homines quamplures, Boves & Oves innumeras demersit*] *Sim. Dunelmensis* (7) Historia.

A D. 1176 [*Mare extra fines in Anglia erumpens multos in Hollandia homines & pecora absorbnit, & quasi*

(1) Invenies sub Aquis, & adhuc ostendere nautæ Inclinata solent cum mœnibus oppida versis.

1 *Metam. Lib. 15.*

(2) Τὰ δὲ ἀνάλογον συμπίπτει τέτοις καὶ ἐν θαλάσσῃ χάσματι γὰρ γίνεσθαι θαλάσσης καὶ ἀναχωρήματα πολλάκις, καὶ κυμάτων ἐπιδηρμαί, ποτὲ μὲν ἀναστροφῇ ἔχουσιν ποτὲ δὲ πρὸς τὴν ἑνὴν, ὥσπερ ἰσχυρίζεται περὶ Ἐλίου τοῦ καὶ Ἐγγον. *Arist. de Mundo.* (3) *Heylin's Geogr. L. 2. In Belgio.* (4) *Laet. Descriptione Belgii, pag. 124.* (5) *Apud Historiæ Anglicanæ Scriptores X. pag. 171.* (6) *Apud eisdem, pag. 892.* (7) *Pag. 224.*

post biduum furore sedato in semet ipsum rediit.] Chronicon Johannis Brompton. (8)

INSOLITAM maris inflationem & commotionem Anno D. 1250. factam, tradit *Matthaus* (9) *Parisiensis*. [Unde Mare perturbatum fines solitos pertransiens, tam horribilem mugitum cum fremitu edidit, ut per remota Terræ spatia, non sine stupore audientium, reboaret. Visum est etiam sub opaca nocte ipsum Fretum quasi accensum ardere, & Fluctus Fluctibus conglomeratos dimicare. Apud Winchelese plusquam 300 domus cum quibusdam Ecclesiis per Maris violentum ascensum sunt submersæ.]

ANNO 1251. inquit idem (10) *Matthaus* [In Frigia (quæ Friselandia appellatur) Aqua Diluvium fecit particulare, occupans Terræ illius spatium itineris circiter septem dierum. Post 40 dies ille damnosus Fluctus in locum suum remeavit.]

ANNO 1286. [Ingruente fortissimo Vento, flante de partibus Orientis, qui & *Eurus* dicitur, & fluxu Maris super provinciam Hollandiæ terribiliter invalescente, prævaluerunt Aqua Maris, adeo ut Fossata, quæ Terram ipsam & Mare determinant, inopinatus quam credi poterat, transgredierentur; posuitque Terram fructiferam in salsuginem tam repentinus Maris impetus; qui per indigenas nullatenus poterat obviari: & maxima pars S. Botolfi submersa, hominumque & pecudum inastimabilis periit multitudo.] Ita Chronicon Tho. (11) *Wikes*.

DE Hollandiæ Inundatione sic *Hadrianus Junius* (12) in *Bataviæ Historia* [Quadringentis abhinc annis inaudita illa Inundatione quæ universam Hollandiæ faciem longe lateque operuit, obstructo fluminis (Rheni) cursu, steriles arenarum colles Litus occuparunt, Mare, Terras, ipsamque Litoris oram attrivit.]

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(8) pag. 1117. (9) Pag. 535. Ed. *Watfiana*. (10) Pag. 549.  
(11) Pag. 114. (12) Pag. 196.

ANNO 1404. quo beatissimus noster *Wiccamus* obiit, [*Tanta repente ruptis limitibus irrupit Aquarum influentia in Cantio, quanta nunquam fuerat illic ante visa, qua submersa sunt animalia numero & pretio excessivo: nec solummodo d flevit Anglia damna talia, sed ut fertur, Scelandia, Flandria & Holandia, per Undarum excrementa, innumerabilia sensit di pendia eo anno.*] Hypodigmate *Neustrie* per *Tho. (13) Walsingham.*

[REGNANTE Edwardo I. cum Oceanus ventorum violentia exasperatus, hunc (Cantii) tractum operuisset, laeq; hominum, pecorum adificiorumque stragem dedisset, & Bromhill viculo frequente pessundato, etiam Rother, qui hic prius se in Oceanum exoneravit, alveo emovit, ostiumque obstruxit, novo in Mare aditu compendio per Rhiam aperto.] Camdenus in *Britanniæ Cantio.*

QUID quod *Tungros*, oppidulum *Leodienf.*, a Mari pene centum milliaria jam remotum, Mare quondam adluere opinati sunt Viri doctissimi, argumento non uno persuasi (14).

NEQUE nostra ætas caruit hujusmodi Exundationibus : Narrant *Novellæ Feb. 27. 1713. in Eff'xia*, plura Terræ jugerum millia, per milliaria aliquot, inter *Barking & Purfleet*, everfis obstaculis, Maris influxu obrui.

HÆC de Oceani *Germanici* exundationibus : *Britannici* nostri, & *Sabrinæ*, neque pauciores, neque minores sunt. Enimvero vidimus ætate nostra Isthmum, uno eodemque *Pedredi* fluxu & refluxu (Terræ superficie prius ab Agricolis semota) dilui, fluviumque veteri cursu relicto novum acquirere: hoc, inquam, unico fluvii illius æstu factum vidimus, nullo auxilium præbente vel Undas adigente Vento.

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(13) Pag. 564. Ed. *Francofurt.* MDCIII. (14) *Verstegan's Antiquities*, pag. 102. *Ray's Physico-Theological Discourses*, 1693. pag. 169.

SABRINÆ fluminis impulsu fieri probabile est Exundationem illam, qua in Agro *Monumetensi*, Parœciæ No. 26. A. D. 1607. mense *Januario* Aquâ obruerentur: Cujus eodem Anno publicata fuit (15) Historiola.

JOHANNE rerum *Anglicarum* potito [*Subita & improvisa Aquarum Inundatio pluribus in locis per Angliam facta est, unde plures homines submersi sunt, & domus eversa, maxime apud Excestre & Sanctum Ivonem*] Imagines Historiarum Autore (16) *Radulfo de Diceto*, [Post diutinam malaciam, mare *Vergivium*, adeo per totam hyemem, regnante tunc *Henrico* secundo, tempestatibus agitabatur, ut toto illo temporis spatio, Navicula nulla ad *Hiberniam* adpulsa, de reliquo terrarum orbe nihil apud eam inauditum. Terror hinc universus, tamquam malo impendente quodam gravi, de cælis misso. Arenarum aggeres, in *Australi Cambria*, quasi Cataclysmo, abluebantur, Litora subvertebantur] *Giraldi Cambrensis* (17) *Hibernia* expugnata.

AT ô quam terribilis illa tempestas, qua, Maris Undam in Oceanum *Britannicum* impellente *Africo*, ita ille turgebat, ut Pharos illa celeberrima, *Eddistone* appellata, quæ fuit e regione *Plimuthæ*, tamquam in contemptum *Æoli Neptunique* fabricata, quasi ludibrio habita simul cum ædificatore dirueretur. Cujus utique tempestatis in hoc nostro Oceano si non eadem vis & potestas esse videatur, atque illarum in prædictis Oceani *Germanici* Exundationibus, propter majorem ab hisce stragem & damnum in *Hollandia Zeelandiaq;* factam; Litoribus hoc nostris rupibus munitis, quæ & duriores & altiores quam apud *Batavos* sunt, deberi judico.

TEMPESTATES (ut argumentum hoc conficiam) quæ in Oceanis *Germanico & Britannico*, nostra

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(15) *Lamentable News from Monmouthshire.* (16) Pag. 710.

(17) Cap. XXXV.

& patrum memoria sæviere, & de quibus omnino constat, adeo fuere turbulentæ, ut si earum aliquæ in Chersonesum, ad hosce dies usque manentem, recta fuissent collineatæ, nullus (ut opinor) esset dubitandi locus, quin a tanta vi auferretur Isthmus: & tot annorum sæculis, quot illico dicentur, revera hoc accidisse nequaquam improbabile videtur.

SIN ex *Americâ* turbo maris æstui superveniat mare, cælum, omnia miscens, omnia confundens, ac si naturæ instaret dissolurio, (posse vero hæc concurrere nemo sanæ mentis ibit inficias) En causam huic negotio parem!

ALTERUM hujus Dissertationis membrum jam aggrediamur, & speciatim inquiramus, utrum exesa fuerit revera hæc Chersonesus; annon. Si de ejus dividendæ modo, qui fieri posset, conveniat, magna inde lux emanabit, unde argumenta, quæ a Viris doctis passim afferuntur, ad divisionis hujus probabilitatem arguendam: egregie confirmabuntur: præmisso nempe (quod hætenus fuit desideratum) Vento, ejusque in elidendo hoc Isthmo virtute omnium causarum maxima, tantoque negotio (cum cæteris) pari Horum ego argumentorum nonnulla persequar; sed leviter tangam, utpote ab aliis fusiùs antehac tractata.

PRIMO. Terræ jugum illud notabile, quod Freto subjicitur, & de quo supra; quid aliud sibi vult, quam quod eo loci Terra olim multo altior esset; at Maris per aliquot annorum millia reciprocationibus, ad eum in quo nunc est statum abluta & detrita? Præcipue, si advertamus Regulam hanc constantem & perpetuæ veritatis esse, *Maris scil. imum, quo magis Oceano præterlabente tritum, (quantum patitur ejus durities) eo magis planum & æquale reddi.*

QUID deinde Rupes in Freto Litoribus oppositis, sive Montes prærupti, albi, ex eadem materia, Calce nimirum & filice compositi, ad sex utrobique milliaria,  
sibi

sibi invicem, tamquam Tesseræ respondentes; quid, inquam, volunt, nisi olim interfringi se, & ablutione Terræ interpositæ distrumpi?

TERTIUM, apprime convenit cum isthac Chersonesi *Britannicæ* opinione, tractus illius, qui hodie *Rümney Marsh* appellatur, ratio & ingenium. Durante enim Isthmo, cum Oceani fluxus eo tamquam obicé sisteretur, æstquare eum necesse erat, atque adeo Terram illam *Rümneienf-m*, utpote planam & humilem in propinquo exundare. Hoc ostendunt Oceani *Britannici* Fluxus, hodieque hac planitie altiores; aggere fortissimo & magnis sumtibus aspulsi: Dentes item ostendunt, atque Ossa, sive Hippopotami sive alius cujusdam marini animalis (18), anno 1668, *Charthami* altitudine pedum 17, dum puteus aperiretur, eruta: at luce clarius ostendit Anchora, non ita pridem ex alto loca hæc circiter effossa. Perrupto autem Isthmo obicæque jam remoto, Oceani unda subsidit, a Terra illa recessit, in alveum se contraxit; unde quæ olim *Æstuarium*, hodie Planities, longa viginti milliaria, lata octo, eaque fertilissima bobus saginandis aptissima reperitur.

NOVISSIME, fac Chersonesum olim fuisse, Lupos, aliaque animalia, generi humano inimica, posse huc migrare, conceptu facillimum est: at si illa non fuit, navigiis ea, tamquam ad ruendas & conservandas eorum species, advehi, stulte cogitabimus?

NEQUE me moratur, quod nulla sive *Latinorum*, sive *Græcorum*, sive alius cujusvis populi Historia Chersonesi hujus abruptæ mentionem fecisse perhibeatur, (quamvis hoc nequaquam ex omni parte verum:) Dic sodes, Historiæ quam brevis sit ætas, si ad ætatem mundi comparetur. A rerum initio ad primam, quæ

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(18) Vide Clariss. *Somneri* Diatribam *Chartham-News* appellatum: *Astorum Philosoph.* No. 272. Et Clariss. *Wallisi* de hac Chersoneso Dissertationem, *Act. Phil.* No. 275.



nunc exstat (i. e. *Herodoti*) Historiam, 3500 circiter anni sunt; & a *Noë Diluvio*, 1800. At tam immenso temporis spatio (quod supra innuimus) quæ *Causarum* accidere possint συζυγίαι; quæque ex iis in orbe nostro fieri mutationes, nemo tam cito statuere debebit.

DIXI hoc nequaquam ex omni parte verum: quid enim planius illo *Virgilii*,

— *Penitus toto divisos orbe Britannos.*

[*Nonne putatis*, (inquit eruditissimus & Antiquitatum Britannicarum scientissimus (19) *Joh. Twiss*) *vocabulum* [divisos] *kabere eam vim ut significat abscissionem alicujus ab aliquo?* Et Auctorem mire gnarum significationis fuisse, & rerum antiquarum maxime peritum, & bene memorem sui? Ad hac verba *Servius* [*Quia olim juncta fuit Orbi Britannia.*] Nihil clarius esse potest ad demonstrandum Isthmi hujus divisionem veteribus fuisse notam. Ut omnino frustra esse *Vossius*, & nimio plus ὑποθέσει δουλεύειν existimetur, cum in Fabellis *Ægyptiacis* (quo nempe suæ opinioni habeatur honos) eam poni voluerit

CONCLUDIMUS ergo e prædictis simul acceptis, *Britanniam non jam inde ab initio fuisse Insulam, sed ex Pene-Insula factam: idque ut videtur, a Vento e sevirioribus aliquo, cum Maris aestu concurrente & Isthmum perrumpente.*

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(19) De rebus *Albionis*, pag. 22.

III. *Extracts from Mr. Gascoigne's and Mr. Crabtree's Letters, proving Mr. Gascoigne to have been the Inventor of the Telescopic Sights of Mathematical Instruments, and not the French. By W. Derham, Prebend of Windsor, and R. Soc. Soc.*

IN *Monsieur de la Hire's* first Part of his *Tabula Astron.* published in 1687. I find an Invention, which was undoubtedly our Countryman Mr. Gascoigne's. ascribed to *Monsieur Picard*, and that is, the Application of Telescopic Sights to Astronomical Instruments. Mr. de la Hire's Words are, *Paucis abhinc annis D. Picard insignis Astronomus, atque in eadem Academia [Regiâ. Scientiarum] Socius, Dioptrarum crenas ab instrumentis sustulit, eorumque loco substituit Telescopia; quæ res Presbytis & Myopibus, &c.* In which Words it is not indeed expressly said that Mr. *Picard* was the Inventor of this way, but only that he applied Telescopes. But by reason it implies that it was that curious and ingenious Gentleman Mr. *Picard's* Invention, and it is in effect claimed as such, in *Monsieur Luzzout's* Account of the Telescopic Micrometer, in the *Philos. Trans* No. 21. therefore I think my self in Duty bound, to do that young but ingenious Gentleman, Mr. Gascoigne, the Justice, to assert his Invention to him; by reason all his Papers, that by the late ingenious Mr. *Torneley's* Diligence could be picked up, are now (together with Mr. *Torneley's* own Papers) in my Hands.

As for the Invention of the Micrometer, which Mr. *Anzout* claims as his and *Monfieur Picard's*, I shall say little to it, Mr. *Towneley* having fufficiently prov'd it to be Mr. *Gascoigne's*, in the *Philos. Transact* No. 25. And the Descriptions and Draughts of that, and some other Instruments of that kind, are now by me, in Mr. *Gascoigne's* own Hand, to confirm Mr. *Towneley's* Account, if occasion were.

And as Mr. *Gascoigne* was the first that measured the Diameters of the Planets, &c. by a Micrometer; so I shall prove that he was the first that applied *Telescopicke Sights* to Astronomical Instruments. In a long Letter to his sagacious Friend Mr. *Crabtree*, of Jan. 25. 1647. (wherein he describes his Micrometer, and shews his way of finding the Refractions, the Moon's Parallax, and how he measured the Diameters of the Planets) Mr. *Gascoigne* tells him how the measuring Glasses, which he had been speaking of, might be applied to a Quadrant. If, saith he, here (that is in the Distinct-Base) you place the Scale that measures —, or, if here an Hair be set, that it appear perfectly through the Glass —, you may use it in a Quadrant, for the finding of the Altitude of the least Star visible by the Perspective wherein it is. If the Night be so dark, that the Hair or the Pointers of the Scale be not to be seen, I place a Candle in a Lanthorn, so as it cast Light sufficient into the Glass; which I find very helpful when the Moon appeareth not, or it is not otherwise light enough.

In another Letter, dated on Christmas Eve 1641. (wherein he describes the Wheel Work of his Micrometer, and shews how he could apply it to the taking of three Points; and specifies his Observations of the Diameters of the Sun and Moon; and mentions a Theory he had contriv'd of the Sun; &c. and saith what pains he had taken in the Anatomy of the Eye) he tells Mr.

*Crab-*

*Crabtrie* how he had applied his Telescopic Sights to a Sextant. Saith he, *Mr. Horrox* his *Theory of the Moon* I shall be shortly furnished to try. For I am fitting my Sextant for all manner of Observations, by two Perspicills with Threads. And also I am consulting my Workman about the making of Wheels like  $\beta$ ,  $\gamma$ ,  $\delta$ ,  $\epsilon$ , of  $\dagger$  *Diagr.* 3, to use two Glasses like a Sector. If I once have my Tools in readiness to my Desire, I shall use them every Night. I have fitted my Sextant by the Help of the Cane, two Glasses in it, and a Thread, so as to be a pleasant Instrument, could Wood and a Country-Joiner or Workman please me.

In another Letter (the Date of which is worn out, but is, in *Mr. Crabtrie's* Hand, called his 10th Letter to him) he saith, I have given order for an Iron Quadrant of Five Foot, which will give me the 1000th Part of One Degree, which shall be furnished like my first Scale; only my Workman is so \*throng for my Father, that I fear it will not be finished before the Eclipse. I have caused a very strong Ruler to be exactly made, and intend to fit it with Cursors of Iron, with Glasses in them and a Thread, for my Sextant.

To these I could have added many other Passages of the like Nature: but these may be sufficient, to shew that *Mr. Gascoigne*, as early as 1640, made use of Telescopes on Quadrants and Sextants, as well as in his Invention of the Micrometer.

What Commendations these Contrivances got him, and what Expectations they raised in some of the Astronomers of that Time, particularly in two of the most acute of that Age, *Mr. Horrox*, and *Mr. Crabtrie*, may be seen in the same *Mr. Crabtrie's* Letters to *Mr. Gascoigne*, which are also in my Hands. Some Passages of which I shall recite, and at the same time give the Society a Taste of what those curious Letters do contain.

$\dagger$  This Diagram is wanting in the Letter.  
for fully employed.

\* A Yorkshire Phrase

In Mr. Crabtree's second Letter, which is of *October 30. 1640*; after a very clear Demonstration that the Solar Spots are not Planets at a Distance from the Sun, but something adhering to, or very near the Sun's Body: and also after a no less clear Demonstration of the Errors of *Lansberges Hipparchian Diagram*, his *Lunar Parallax*, his Doctrine of *Eclipses*, and indeed his whole *Lunar Astronomy*, together with divers other curious Matters, too many to be specified: after this, I say, Mr. Crabtree saith thus, *Something I am sure you were telling me concerning a way of observing the Places of the Planets by your Glasses. But I have not a little lamented that my Time cut me so short, when I was with you, that I could not more fully ruminare and digest those strange Inventions which you shewed me, and told me of. My Lassitude after an unexpected and unacquainted Journey; my unpreparedness for those Cogitations (not intending that Journey the Day before) and the Multiplicity and Variety of the Novelities you shewed me, so wholly distracted my Thoughts into Admiration, that I cannot now give my Meditations any reasonable Account of what I saw: but must intreat you, in a few Lines, to rub up my Memory, and tell me again what you shewed me, and the Extent of those your Inventions. Which I desire, that I might consider, and rejoice to consider, how much and wherein Urania's Structure will grow to Perfection by your Assistance: and that (what in me lies) I may help you to remember when and wherein your Inventions and Observations will be of most use. I should also desire you to inform me what Bigness of a Quadrant you conceive to be large enough for Observation with your Devices. For I am ere long going to Wigan, 12 Miles from hence, where much Brass is cast; and then I could see whether I could procure such an one cast. You told me (as I remember) you doubted not in time to be able to make Observations to Seconds. I cannot but admire it and yet, by what I saw, believe it: but long*

to have some farther Hints of your Conceit for that Purpose. One Means, I think, you told me was, by a single Glass in a Cane, upon the Index of your Sextant, by which (as I remember) you find the exact Point of the Sun's Rays. But the way how, I have quite forgotten, and much desire: Your Device for the exact Division of a Quadrant, by dividing 11 Degrees into 10 Parts, I did then understand, but do not now fully remember. If it might not be too much Trouble to you, I should intreat you to give me such a Paper-Demonstration thereof as you shewed me, and two or three Lines plainly of the Use thereof, how to find those small Parts. I lost the little Paper, wherein I noted the Moon's Diameter, which we observed when I was with you: I pray you send it me, if, &c.

I cannot conceal how much I am transported beyond myself with the Remembrance (of that little I do remember) of those admirable Inventions which you shewed me when I was with you. I should not have believed the World could have afforded such exquisite Rarities, and I know not how to stint my longing Desires, without some further Taste of these selected Dainties. Happier had I been, had I never known there had been such Secrets, than to know no more, but only that there are such. Of all Desires the Desire of Knowledge is most vehement, most impatient: and of all kinds of Knowledge, this of the Mathematicks affects the Mind with most intense Agitations. I doubt not but you can experimentally witness the Truth hereof, and one time or other have been no Stranger to such Thoughts as mine. And therefore although Modesty would forbid me to request any thing (until you give me leave) but what you please voluntarily to impart, yet the Vehemence of my Desire forceth me to let you know how much I desire, and how highly I should prize any thing that you should be pleased to communicate to me in those Optick Practices. Could I purchase it with Travel, or procure it for Gold, I would not long be without a Telescope for observing

*serv'ing small Angles in the Heavens ; nor want the Use of your other Device of a Glaſs in a Cane upon the moveable Ruler of your Sextant (as I remember) for helping to the exact Point of the Sun's Rays. But seeing Urania is, &c.*

Thus was the most ingenious Mr. Crabtree transported with Mr. Gascoigne's Devices, although at that time far less perfect than they were in a short Time after. And no less affected was the incomparable Horrox, as Mr. Crabtree sets forth, in his third long Letter of Dec. 28. 1640. which hath these Words, *My Friend Mr. Horrox professeth, that little Touch which I gave him of your Inventions, hath ravished his Mind quite from it self, and left him in an Extasie between Admiration and Amazement. I beseech you, Sir, stick not your Intentions for the perfecting of your begun Wonders. We travel with Desire till we hear of your full Delivery. You have our Votes, our Hearts, and our Hands should not be wanting, if we could further you. And then after many curious Matters (which would take up too much of the Societies time to relate) he thus proceeds, Your Diagrams for Perspectives I have viewed again and again, and cannot sufficiently admire your indefatigable Industry, and profound Ingenuity therein. I am much affected with the Symbolical Expressions of your Demonstrations. I never used them before (but I will do) yet I understand them all at the first Sight, and see well the Truth of your Demonstrations.*

To these I shall only add one Passage more, and this because it shews some other of Mr. Gascoigne's exquisite Contrivances, or at least the Accuracy of what are mentioned ; and that is in Mr. Crabtree's Letter of Dec: 6. 1641. at the Beginning of which he saith, *That which you give me a full Projection of was above my Hope : and if the Screws keep an exact Equality of Motion forward in each Revolve, it is a most admirable Invention ; and with the other Accommodations, I had almost said without*

*Com-*

*Compare. But that the Divisions of a Circle should be measured to Seconds, without the Limb of an Instrument, or that Distances, Altitudes, Inclinations, and Azimuths should be taken all at one Moment, without the Limb of an Instrument likewise, and each to any required Number of Parts; or that the Diameter of Jupiter should be projected in such prodigious Measures as you speak of, &c. were enough to amuse and amaze all the Mathematicians in Europe, and may indeed be rather a Subject of Admiration than Belief, to any that hath not known your former Inventions to exceed Vulgar (I had almost said Humane) Abilities. And for my Part, I must confess Modesty so checks my ambitious Desires, that I dare scarce hope such Miracles should ever be produced in real Practice to such Exactness. Then (to give the Society a further Taste of those Letters) follows an Account of the Agreement of Mr. Horrox's Theory of the Moon with Mr. Gascoigne's Observations; and also very curious Ratiocinations, and a Disquisition about finding the Parallax of the Sun and Moon, and their Distance from the Earth. In which he censures Morinus's Braggs, &c. and then saith, that no Man that hath written of the Diagram [of Hipparchus] understood it fully, or described it rightly, but only Kepler and our Horrox; for whose immature Death [which was suddenly, and about the Age of 25.] there is yet scarce a Day which I pass without some Pang of Sorrow.*

Thus, among many, I have related some of the Passages of Mr. Gascoigne's and Mr. Crabtree's Letters relating to *Telescopick Sights*. From whence it is very manifest, that long before the *French Gentleman's Claims*, our Countryman Mr. Gascoigne had made use of those Sights in his Astronomical Instruments; particularly in two or more Sorts of *Micrometers* (as I plainly find) and in his *Quadrant* and *Sextant*. And had it pleased God to have given him a longer Life, we might have expected,



pected greater things from his pregnant and sagacious Wit. For he was scarce 20 Years of Age when he held these Correspondencies with Mr. Crabtree. And at the Age of 23. he was killed at *Marston-Moor-Battle*, on July 2. 1644. fighting for King Charles I. His Father was *Henry Gascoigne Esq;* of *Middleton*, between *Leeds* and *Wakefield*.

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IV. *An Attempt towards the Improvement of the Method of approximating, in the Extraction of the Roots of Equations in Numbers. By Brook Taylor, Secretary to the Royal Society.*

IN *Phil. Tran.* No. 210. Dr. Halley, now Secretary of the Royal Society. has publish'd a very compendious and useful Method of extracting the Roots of affected Equations of the common Form, in Numbers. This Method proceeds by assuming the Root desired nearly true to one or two Places in Decimals (which is done by a Geometrical Construction. or by some other convenient way) and correcting the Assumption by comparing the Difference between the true Root and the assumed, by means of a new Equation whose Root is that Difference, and which he shews how to form from the Equation proposed, by Substitution of the Value of the Root sought, partly in known and partly in unknown Terms.

In doing this he makes use of a Table of Products (which he calls *Speculum Analyticum*.) by which he computes the Coefficients in the new Equation for finding the Difference mentioned. This Table, I observed, was formed in the same Manner from the Equation  
pro-

propos'd, as the Fluxions are, taking the Root sought for the only flowing Quantity, its Fluxion for Unity, and after every Operation dividing the Product successively by the Numbers 1, 2, 3, 4, &c. Hence I soon found that this Method might easily and naturally be drawn from *Cor. 2. Prop. 7.* of my *Methodus Incrementorum*, and that it was capable of a further degree of Generality; it being Applicable, not only to Equations of the common Form, (*viz.* such as consist of Terms wherein the Powers of the Root sought are positive and integral, without any Radical Sign) but also to all Expressions in general, wherein any thing is proposed as given which by any known Method might be computed; if *vice versâ*, the Root were consider'd as given: such as are all Radical Expressions of Binomials, Trinomials, or of any other Nomial, which may be computed by the Root given, at least by Logarithms, whatever be the Index of the Power of that Nomial; as likewise Expressions of Logarithms, of Arches by the Sines or Tangents, of Areas of Curves by the *Abseissa's* or any other Fluents, or Roots of Fluxional Equations, &c.

For the sake of this great Generality, it may not be improper to shew how this Method is derived from the foresaid *Corollary*. Therefore  $z$  and  $x$  being two flowing Quantities (whose Relation to one another may be expressed by any Equation whatsoever) by this *Corollary*, while  $z$  by flowing uniformly becomes  $z + v$ ,  $x$  will

$$\text{become } x + \frac{\dot{x}}{1 \cdot \dot{z}} v + \frac{\ddot{x}}{1 \cdot 2 \dot{z}^2} v^2 + \frac{\ddot{\ddot{x}}}{1 \cdot 2 \cdot 3 \dot{z}^3} v^3 + \&c.$$

$$\text{or } x + \frac{\dot{x} v}{1} + \frac{\ddot{x} v^2}{1 \times 2} + \frac{\ddot{\ddot{x}} v^3}{1 \cdot 2 \cdot 3} + \&c. \text{ for } \dot{z} \text{ putting } 1.$$

Hence if  $y$  be the Root of any Expression formed of  $y$  and known Quantities, and supposed equal to nothing,  
and

and  $z$  be a part of  $y$ , and  $x$  be formed of  $z$  and the known Quantities, in the same manner as the Expression made equal to nothing is formed of  $y$ ; and let  $y$  be equal to  $z + v$ : the difference  $v$  will be found by Extracting

the Root of this expression  $x + \frac{\dot{x}v}{1} + \frac{\ddot{x}v^2}{1.2} + \frac{\ddot{\dot{x}}v^3}{1.2.3} + \text{&c.} = 0$ . For in this Case  $z$  being become  $z + v = y$ ,  $x$ , which is now become  $x + \dot{x}v + \frac{\ddot{x}v^2}{2} + \text{&c.}$

must become equal to nothing.

The Root  $v$  in the Equation  $x + \frac{\dot{x}v}{1} + \frac{\ddot{x}v^2}{1.2} + \frac{\ddot{\dot{x}}v^3}{1.2.3} + \text{&c.} = 0$ , is to be found upon the Supposition of its being very small with respect to  $z$ , (as it must be, if  $z$  be taken tolerably exact) by which means the Terms  $\frac{\ddot{\dot{x}}v^3}{1.2.3} + \frac{\ddot{\ddot{x}}v^4}{1.2.3.4} + \text{&c.}$  may be neglected, upon account of their smallness with respect to the other Terms, so as to leave the Equation  $x + \frac{\dot{x}v}{1} + \frac{\ddot{x}v^2}{1.2} = 0$ , for finding the first approximation of  $v$ .

By extracting the Root of this Equation, we have

$$v = \sqrt{\frac{\ddot{x}^2}{\ddot{\ddot{x}}^2} - \frac{2x}{\ddot{x}} - \frac{\dot{x}}{\ddot{x}}}. \text{ That is,}$$

$$\text{First, } \sqrt{\frac{\ddot{x}^2}{\ddot{\ddot{x}}^2} - \frac{2x}{\ddot{x}} - \frac{\dot{x}}{\ddot{x}}}, \text{ if } x + \dot{x}v + \frac{\ddot{x}v^2}{2} = 0.$$

$$\text{Sec. } \sqrt{\frac{\ddot{x}^2}{\ddot{\ddot{x}}^2} + \frac{2x}{\ddot{x}} - \frac{\dot{x}}{\ddot{x}}}, \text{ if } -x + \dot{x}v + \frac{\ddot{x}v^2}{2} = 0.$$

Thirdly



more exactly  $v = \frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$ , that is

$$1. \frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}, \text{ when } x + \dot{x}v + \frac{\ddot{x}v^2}{2} \text{ } \mathcal{C}c. = 0.$$

$$2. \frac{x}{\dot{x} + \frac{\ddot{x}x}{2\dot{x}}}, \text{ when } -x + \dot{x}v + \frac{\ddot{x}v^2}{2} \text{ } \mathcal{C}c. = 0.$$

$$3. \frac{x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}, \text{ when } x - \dot{x}v + \frac{\ddot{x}v^2}{2} \text{ } \mathcal{C}c. = 0.$$

$$4. \frac{-x}{\dot{x} + \frac{\ddot{x}x}{2\dot{x}}}, \text{ when } -x - \dot{x}v + \frac{\ddot{x}v^2}{2} \text{ } \mathcal{C}c. = 0.$$

This *Formula* will also triplicate the number of true Figures in  $z$ . And the Calculation may be repeated, af-

ter every Operation, taking for a Divisor  $\dot{x} \pm \frac{\ddot{x}}{2} v +$

$$\frac{\ddot{x}v^2}{1.2.3} + \frac{\ddot{x}v^3}{1.2.3.4} + \mathcal{C}c. \text{ instead of } x + \frac{\ddot{x}x}{2\dot{x}}.$$

Dr. *Halley* has fully explain'd the manner of using both these *Formula's* in *Equations* of the common Form; wherefore I shall be the shorter in explaining two or three Examples of another sort.

*Ex. 1.* Let it be propos'd to find the Root of this Equation  $y^2 + 1|^{v^2} + y - 16 = 0$ . In this Case, for  $y$  writing  $z$ , and for 0 writing  $x$ , we have  $z^2 + 1|^{v^2} + z - 16 = 0$ .

$+z-16=x$ . Whence by taking the Fluxions, we have  $\dot{x}=2\sqrt{2}\times z\times z^2+1|^{\sqrt{2}-1}+1$ , and  $\ddot{x}=2\sqrt{2}\times 8-4\sqrt{2}\times z^2\times z^2+1|^{\sqrt{2}-2}$ . For finding the first Figures of the Root  $y$ , for  $\sqrt{2}$  take  $\frac{7}{5}$ , and we

have the Equation  $y^2+1|^{\frac{7}{5}}+y-16=0$ , which being expanded gives  $y^6+3y^4+2y^2+32y-255=0$ .

By this Equation I find that for the first supposition we may take  $z=2$ . Therefore in order to find  $v$ , let us now make  $\sqrt{2}=\frac{7}{5}$ , (which is nearer than before)

and we have  $x=\overline{z^2+1|^{\frac{7}{5}}}+z-16=\overline{2^2+1|^{\frac{7}{5}}}-14=5^{\frac{7}{5}}-14=-4,48$ ;  $\dot{x}=10,66$ ;  $\ddot{x}=4,72$ . Whence

by the second rational Form  $v=\frac{4,48}{10,66+\frac{4,72\times 4,48}{2\times 10,66}}$

$=0,38$ ; which must be too big, because  $\frac{7}{5}<\sqrt{2}$ , and therefore will require a larger Value of  $y$  to exhaust the Equation, than where  $\sqrt{2}$  is exact. For the second supposition therefore, let us take  $z=2,3$ , and make  $\sqrt{2}=1,4142136$ , and by help of the Logarithms we shall have  $z^2+1|^{\sqrt{2}}=13,47294$ , whence  $x=-0,22706$ ;  $\dot{x}=14,93429$ , and  $\ddot{x}=5,18419$ . Hence by the 2<sup>d</sup>.

irrational Formula  $v=\sqrt{\frac{14,93429^2}{5,18419^2}+\frac{0,45412}{5,18419}}$

$=\frac{14,93429}{5,18419}=0,01516$ , which gives  $y=z+v=$

$2,31516$ , which is true to six Places. If you desire it more exact than to the extent of the Tables of Logarithms, taking  $z=2,31516$  for the next supposition, the Calculation must be repeated by computing of  $z^2+1|^{\sqrt{2}}$  to a sufficient number of Places; which must be done by the Binomial Series, or by making a Logarithm

arithm on purpose, true to as many places as are necessary.

*Ex. II.* For another Example, let it be required to find the Number whose Logarithm is 0, 29, supposing we had no other Table of Logarithms but Mr. Sharps of 200 Logarithms to a great many places. This amounts to the resolving this Equation  $ly = 0, 29$ , or  $ly - 0, 29 = 0$ .

Hence therefore we have  $x = ly - 0, 29$ ,  $\dot{x} = \frac{a}{z}$  ( $a$  being the *Modulus* belonging to the Table we use, viz: 0, 4342944819, &c.)  $\ddot{x} = \frac{-a}{z^2}$ ,  $\ddot{\dot{x}} = \frac{2a}{z^3}$ ,  $\ddot{\ddot{x}} = \frac{-6a}{z^4}$

&c. In this Case because  $\ddot{x}$  has a negative Sign, changing the Signs of all the Coefficients, the Canon for  $v$  will be found in the fourth Case, which in the irrational Form

$$\text{gives } v = \frac{\dot{x}}{\ddot{x}} - \sqrt{\frac{\dot{x}^2}{\ddot{x}^2} + \frac{2\dot{x}}{\ddot{x}} - \frac{2\ddot{x}}{2.3\ddot{x}}v^3 - \frac{2\ddot{\dot{x}}}{2.3.4\ddot{x}}v^4}$$

$$\text{&c.} = z - \sqrt{z^2 + \frac{2ly - 0, 58}{a} \times z^2 + \frac{2v^3}{3z} - \frac{2v^4}{4z^2}}$$

$$+ \frac{2v^5}{5z^3} \text{ &c. In this Case to avoid often dividing by } z, \text{ it}$$

will be most convenient to compute  $\frac{v}{z}$ , which is got

$$\text{from this Equation } \frac{v}{z} = 1 - \sqrt{1 + \frac{2ly - 0, 58}{a} +}$$

$$\frac{2v^3}{3z^3} - \frac{2v^4}{4z^4} + \frac{2v^5}{5z^5}, \text{ &c. The nearest Logarithm, in}$$

the Tables proposed, to the proposed Logarithm 0, 29 is 0, 2900346114, its Number being 1, 95. Therefore for the first supposition taking  $z = 1, 95$ , we have  $x (= ly - 0, 29 = 0, 2900346114 - 0, 29) =$   
0, 0000

( 617 )

$$0,0000346114, \text{ and } \frac{2lz - 0,58}{a} = \frac{0,0000692228}{0,4342944819} =$$

$$0,00015939139, \text{ and } 1 + \frac{2lz - 0,58}{a} = 1,000159$$

39139 Whence for the first approximation we have

$$\frac{v}{z} = 1 - \sqrt{1,00015939139} = -0,00007969247,$$

$$\text{and } v = -0,00015540032, \text{ and } y = z + v = 1,94984459968. \text{ Which is true to eleven places, and}$$

may easily be corrected by the Terms  $\frac{2v^3}{3z} \&c.$  which I

leave to the Readers curiosity.

Being upon the Subject of Approximations, it may not be amiss to set down here two Approximations I have formerly hit upon. The one is a Series of Terms for expressing the Root of any Quadratick Equation: and the other is a particular Method of Approximating in the invention of Logarithms, which has no occasion for any of the Transcendental Methods, and is expeditious enough for making the Tables without much trouble.

*A general Series for expressing the Root of any Quadratick Equation:*

Any Quadratick Equation being reduc'd to this Form  $xx - mqx + my = 0$ , the Root  $x$  will be express'd by this Series of Terms.

$$x = \frac{y}{q} + A \times \frac{1}{\frac{mq^2}{y} - 2} + B \times \frac{1}{a^2 - 2} + C \times \frac{1}{b^2 - 2} + D \times \frac{1}{c^2 - 2} \&c. \text{ Which must be thus interpreted.}$$

1. The Capital Letters A, B, C, &c. stand for the whole Terms with their Signs, preceding those where-  
in



in they are found, as  $B = A \times \frac{1}{\frac{mq^2}{y} - 2}$ .

2. The little Letters  $a, b, c, \&c.$  in the Divisors, are equal to the whole Divisors of the Fraction in the Terms immediately preceding; thus  $b = a^2 - 2$ .

For an Example of this, let it be required to find  $\sqrt{2}$ . Putting  $\sqrt{2} = x + 1$ , we have  $x^2 + 2x - 1 = 0$ , which being compared with the general *Formula*, gives  $mq = -2$ , and  $my = -1$ : therefore for  $m$  taking  $-1$ , we have  $q = 2$ , and  $y = 1$ , which Values substituted in the Series give  $x = \frac{1}{2} - \frac{1}{2 \times 6} + \frac{1}{2 \times 6 \times 34}$

$- \frac{1}{2 \times 6 \times 34 \times 1154} + \frac{1}{2 \times 6 \times 34 \times 1154 \times 1331714},$   
*&c.* The Fractions here wrote down giving the Root true to twenty three Places.

*A new Method of computing Logarithms.*

This Method is founded upon these Considerations.

1. That the Sum of the Logarithms of any two Numbers is the Logarithm of the Product of those two Numbers Multiplied together.

2. That the Logarithm of Unite is nothing; and consequently that the nearer any Number is to Unite, the nearer will its Logarithm be to 0. 3<sup>dly</sup>. That the Product by Multiplication of two Numbers, whereof one is bigger, and the other less than Unite, is nearer to Unite than that of the two Numbers which is on the same side of Unite with its self; for Example the two Numbers being  $\frac{3}{2}$  and  $\frac{4}{3}$ , the Product  $\frac{8}{3}$  is less than Unite, but nearer to it than  $\frac{3}{2}$ , which is also less than Unite. Upon these Considerations, I found the present Approximation;

proximation; which will be best explain'd by an Example. Let it therefore be propos'd to find the Relation of the Logarithms of 2 and of 10. In order to this, I take two Fractions  $\frac{128}{100}$  and  $\frac{8}{10}$ , viz.  $\frac{2^7}{10^2}$  and  $\frac{2^3}{10^1}$

whose Numerators are Powers of 2, and their Denominators Powers of 10; one of them being bigger, and the other less than 1. Having set these down in Decimal Fractions in the first Column of the Table annex'd, against them in the second Column I set A and B for their Logarithms, expressing by an Equation the manner how they are Compounded of the Logarithms of 2 and 10, for which I write  $7/2$  and  $3/10$ . Then Multiplying the two Numbers in the first Column together, I have a third Number 1,024, against which I write C for its Logarithm, expressing like wise by an Equation in what manner C is formed of the foregoing Logarithms A and B. And in the same manner the Calculation is continued; only observing this *Compendium*, that before I Multiply the two last Numbers already got in the Table, I consider what Power of one of them must be used to bring the Product the nearest to Unite that can be. This is found, after we have gone a little way in the Table, only by Dividing the Differences of the Numbers from Unite one by the other, and taking the Quotient with the nearest, for the Index of the Power wanted. Thus the two last Numbers in the Table being 0,8 and 1,024, their Differences from Unit are 0,200 and 0,024; therefore

$\frac{0,200}{0,024}$  gives 9 for the Index; wherefore Multiplying the ninth Power of 1,024 by 0,8, I have the next Number 0,990352031429, whose logarithm is  $D = 9C - B$ . In seeking the Index in this manner by Division of the Differences, the Quotient ought generally to be taken with

with the least: but in the present case it happens to be the most, because instead of the Difference between 0, 8 and 1, we ought strictly to have taken the difference between the reciprocal 1, 25 and 1, which would have given the Index 105; and that would be too big, because the Product by that means would have been bigger than 1, as 1,024 is. Whereas this Approximation requires that the Numbers in the first Column be alternately greater and less than 1, as may be seen in the Table.

When I have in this manner continued the Calculation, till I have got the Numbers small enough, I suppose the last Logarithm to be equal to nothing. Which gives me an Equation, from which having got away the Letters by means of the foregoing Equations, I have the relation of the Logarithms proposed. In this manner if I suppose  $G = 0$ , I have  $2136 / 2 - 643 / 10 = 0$ . Which gives the Logarithm of 2 true in seven Figures, and too big in the Eighth; which happens because the Number corresponding with  $G$  is bigger than Unite.

There is another Expedient which renders this Calculation still shorter. It is founded upon this Consideration, that when  $x$  is very small  $1 + x^n$  is very nearly  $1 + nx$ . Hence if  $1 + x$ , and  $1 - z$  are the two last Numbers already got in the first Column of the Table, and their Powers  $1 + x^m$  and  $1 - z^n$  are such as will make the Product  $1 + x^m \times 1 - z^n$  very near to Unite,  $m$  and  $n$  may be found thus:  $1 + x^m = 1 + mx$ , and  $1 - z^n = 1 - nz$ , and consequently  $1 + x^m \times 1 - z^n = 1 + mx - nz - mnzx$ , or (neglecting  $mnzx$ )  $1 + mx - nz$ . Make this equal to 1, and we have  $m:n::z:x::1 - z:1 + x$ . Whence  $x / 1 - z = z / 1 + x = 0$ . To give an Example of the Application of this, let 1,024 and 0,990352 be the last Numbers in the Table, their Logarithms being C and D. Then we have

$x, 024 = 1 + x$ , and  $0, 990352 = 1 - x$ , and consequently  $x = 0, 024$ , and  $x = 0, 009648$ . Whence the Ratio  $\frac{x}{x}$  in the least Numbers is  $\frac{201}{500}$ . So that for finding the

Logarithms proposed we may have  $500 D + 201 C = 48510 l 2 - 14603 l 10 = 0$ , which gives  $l 2 = 0, 3010307$ , which is too big in the last Figure; but it is nearer the truth, than what is got from the Logarithm F supposed equal to nothing. So that by this means we have saved four Multiplications, which were necessary to find the Number  $99895952c$ . correspondent to F, and which must have been had if we would make the Logarithm true to the same Number of places without this *Compendium*.

( 621 )

1, 280000000000	A = 7 l 2 — 2 l 10 — — — — —	l 2 > 0, 28
0, 800000000000	B = 3 l 2 — 1 l 10 — — — — —	< 0, 33
1, 024000000000	C = B + A = 10 l 2 — 3 l 10 — — — — —	> 0, 300
0, 990352031429	D = 9 — + B = 93 l 2 — 28 l 10 — — — — —	< 0, 30107
1, 004336277664	E = 2 D + C = 196 l 2 — 59 l 10 — — — — —	> 0, 301020
0, 998959536107	F = 2 E + D = 485 l 2 — 146 l 10 — — — — —	< 0, 3010309
1, 000162894165	G = 4 F + E = 2136 l 2 — 643 l 10 — — — — —	> 0, 30102996
0, 999936281874	H = 6 G + F = 13301 l 2 — 4004 l 10 — — — — —	< 0, 301029997
1, 000035441215	I = 2 H + G = 28738 l 2 — 8651 l 10 — — — — —	> 0, 3010299951
0, 999971720830	K = I + H = 42039 l 2 — 12655 l 10 — — — — —	< 0, 3010299959
1, 000007161046	L = K + I = 70777 l 2 — 21306 l 10 — — — — —	> 0, 30102999562
0, 999993203514	M = 3 L + K = 254370 l 2 — 76573 l 10 — — — — —	< 0, 30102999567
1, 00000364511	N = M + L = 325147 l 2 — 97879 l 10 — — — — —	> 0, 3010299956635
0, 99999764687	O = 18 N + M = 6107016 l 2 — 1838395 l 10 — — — — —	< 0, 3010299956640
Com. Ar. 235313		
0 = 364511 O + 235313 N = 2302585825187 l 2 — 693147400972 l 10		> 0, 301029995663987

I have computed this Table so far, that the Reader may see in what manner this Method Approximates; this whole Work, as it appears, costing a little more than three Hours time.

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V. *Proprietates quædam simplices Sectionum Conicarum ex natura Focorum deductæ; cum Theoremate generali de Viribus Centripetis; quorum ope Lex Virium Centripetarum ad Focos Sectionum tendentium, Velocitates Corporum in illis revolvantium, & Descriptio Orbium facillime determinantur. Per Abr. de Moivre. R. S. Soc.*

**S**IT  $DE$  Axis Transversus Ellipseos,  $AO$  Axis alter, &  $C$  centrum Sectionis. Sit  $P$  punctum quodvis in circumferentia ejus;  $PQ$  Tangens curvæ ad  $P$ , occurrens Axi Transverso ad  $Q$ ; puncta  $S, F$  Foci;  $CP, CK$  semidiametri Conjugatæ;  $PH$  Semilatus rectum ad diametrum  $PC$ ;  $PG$  normalis ad Tangentem, cui occurrat  $HG$ , perpendicularis ipsi  $PC$  in puncto  $G$ , ut fiat  $PG$  radius Curvaturæ Ellipseos in puncto  $P$ : sint etiam  $ST, CR, FV$  perpendiculares in Tangentem  $PQ$  demissæ: Jungatur  $SO$ , & demittatur in Axem normalis  $PL$ . His positis, Dico quod,

I. Rectangulum sub distantis ab utroque Ellipseos Foco, sive  $SP \times PF$  æquale est quadrato Semidiametri  $CK$ .

*Demonstratio.*

$$PSq = PCq + CSq - 2CS \times CL \text{ per 13. II. Elem.}$$

$$PFq = PCq + CSq + 2CS \times CL \text{ per 12. II. Elem.}$$

$$\text{Unde } PSq + PFq = 2PCq + 2CSq.$$

$$\text{Jam } PS + PF = DE = 2CD; \text{ ac propterea}$$

$$PSq + PFq + 2PS \times PF = 4CDq. \quad \text{Quare}$$

Quare transponendo,  $2PS \times PF = 4CDq - 2PCq - 2CSq$ .

Ac Dimidiando  $PS \times PF = 2CDq - PCq - CSq$ .

Est autem  $CS \text{ quad.} = CD \text{ quad.} - CO \text{ quad.}$ , atque adeo

$PS \times PF = 2CDq + COq - PCq$ .

Sed  $CDq + COq = PCq + CKq$ . per 12. VII. Conic. Apollonii.

Quare  $PS \times PF = CKq$ . Q. E. D.

II. Distantia à Foco  $SP$  est ad perpendicularem in Tangentem demissam, ut Semidiameter Conjugata  $CK$  ad Semiaxem minorem  $CO$ .

*Demonstratio.*

Ob similia Triangula  $SPT$ ,  $FPV$ , erit  $PS : PF :: ST : FV$ ; ac componendo  $PS + PF$  erit ad  $ST + FV$ , & earundem dimidia  $CD$  ad  $CR$ , ut  $PS$  ad  $ST$ . Unde  $CD \times CK$  erit ad  $CR \times CK$  ut  $PS$  ad  $ST$ . Sed  $CR \times CK$  æquale est rectangulo sub Semiaxibus  $CD$  in  $CO$ , per 31. VII. Conic. Proinde  $PS$  est ad  $ST$  ut  $CD$  in  $CK$  ad  $CD \times CO$ , sive ut  $CK$  ad  $CO$ . Ac pari argumento demonstrabitur  $PF$  esse ad  $FV$  in eadem ratione. Q. E. D.

III. In eadem etiam est ratione Semiaxis Transversus  $CD$  ad normalem à centro  $C$  ad Tangentem demissam, sive ad  $CR$ .

Etenim cum rectangulum  $CR \times CK$  æquale sit rectangulo  $CD \times CO$ , uti jam dictum est, erit ἀνέλογον  $CD$  ad  $CR$  ut  $CK$  ad  $CO$ . Q. E. D.

IV. Semidiameter quævis  $PC$  est ad distantiam puncti  $P$  à foco  $S$ , sive ad  $SP$ , ut distantia ab altero Foco  $FP$  ad dimidium lateris recti ad Verticem  $P$  pertinentis, sive ad  $PH$ .

Hoc autem manifestum est ob Propr. I. cum nempe quadratum ex  $CK$  æquale sit rectangulo sub  $SP \times PF$ .

V. Rectangulum Semiaxium  $CD \times CO$  est ad quadratum semidiametri conjugatæ  $CK$ , ut  $CK$  ad Radium Curvaturæ in puncto  $P$ , sive ad  $PG$ .

Sunt

Sunt enim Triangula  $PCR$ ,  $PGH$  inter se similia,  
unde  $CR$  est ad  $PC$ , ut semilatus rectum  $PH$  ad  $PG$ :  
hoc est, per præmissam Proprietatem III,  $\frac{CD \times CO}{CK} =$   
 $CR$  est ad  $PC$  ut  $\frac{CK^2}{PC} = PH$  ad  $\frac{CK^3}{CD \times CO} = PG$ .  
proinde ἀνάλογον  $CD \times CO : CK^2 :: CK : PG$ .  $\text{Q.E.D.}$

## THEOREMA GENERALE I.

*Vis centripeta ad idem punctum S tendens, in Curvis omnibus, est semper proportionalis Quantitati  $\frac{SP}{PG \times ST^3}$*

Hoc Theorema ante plures annos à me investigatum & cum amicis communicatum, propriis demonstrationibus firmavere Geometræ Clarissimi D. J. Bernoullius in *Act. Lipsiæ*; D. J. Keillius in harum *Transact.* N. 317. & D. Jac. Hermannus in *Phoronomiâ* suâ pag. 70. quos vide.

Scribendo autem  $CK^3$  pro  $PG$ , per *Propr. V*; &  $\frac{SP}{CK}$  juxta *Propr. II*, pro  $ST$ ; (ob datas scilicet  $CD, CO$ ) erit *Vis centripeta* tendens ad focum Ellipseos  $S$ , semper ut  $\frac{SP \times CK^3}{CK^3 \times ST^3}$ , hoc est ut  $\frac{SP}{SP^3}$  vel  $\frac{1}{SP^2}$ , nempe reciprocè ut quadratum ex  $SP$ . Unde patet quod si Sectio fuerit Ellipsis motu corporis descripta, erit *Vis Centripeta* ut quadratum distantiae à centro Virium reciprocè. Ex his *Proprietatibus* consequuntur *Corollaria* nonnulla notatu non indigna.

Coroll. 1. *Velocitas Corporis in Ellipsi revolvantis, ad punctum quodlibet P, est ad Velocitatem revolvantis in circulo ad eandem distantiam SP à centro Virium, in subdpla ratione distantia ab altero foco PF, ad Semiaxem transversum Sectionis, sive ut media proportionalis inter PF & CD ad CD.*

Est enim velocitas revolventis in Ellipsi ad distantiam  $SP$ , ad Velocitatem revolventis in Circulo vel Ellipsi ad dist.

distantiam Semiaxis  $CD$  vel  $SO$ , ut  $CO$  ad  $ST$ ; hoc est per *Propr. II.* ut  $\sqrt{PF}$  ad  $\sqrt{SP}$ . Velocitas autem revolvantis in Circulo ad distantiam  $CD$  est ad velocitatem revolvantis in Circulo ad distantiam  $SP$ , ut  $\sqrt{SP}$  ad  $\sqrt{CD}$ . Ex æquo igitur, Velocitas revolvantis in Ellipsi ad distantiam  $SP$ , est ad Velocitatem revolvantis in Circulo ad eandem distantiam ut  $\sqrt{PF}$  ad  $\sqrt{CD}$ .

*Coroll. 2. Ex datis Velocitate in Ellipsi, positione Tangentis, & centro Virium seu Foco, facile est determinare Focum alterum.*

Sit enim Velocitas Data  $R$ ; ea autem Velocitas quâ describeretur Circulus ad datam à centro distantiam  $SP$  sit  $Q$ ; ac per *Coroll. præcedens*,  $R$  est ad  $Q$  ut  $\sqrt{PF}$  ad  $\sqrt{CD}$ , adeoque  $Q^2$  est ad  $RR$  ut  $CD$  ad  $PF$ , &  $2 Q^2 - RR$  erit ad  $RR$  ut  $SP$  ad  $PF$ : Datur autem  $SP$ ; data est igitur  $PF$  magnitudine. Datur etiam positione, ob angulum  $VPF$  angulo  $SPT$  æqualem. Datur igitur punctum  $F$  alter Focorum: Quo invento primum est Sectionem describere.

Si vero  $\frac{1}{2} RR$  majus fuerit quadrato ex  $Q$ ,  $2 Q^2 - RR$  fit quantitas Negativa, & loco Ellipseos Trajectoria describenda in Hyperbolam transit. Eritque  $RR - 2 Q^2$  ad  $RR$  ut  $SP$  ad  $PF$  distantiam alterius Foci, ad alterum Tangentis latus ponendam, ut habeatur Focus  $F$ . Proprietates autem omnes quas in Ellipsi demonstravimus; mutatis mutandis etiam Hyperbolæ competunt. *Fig. II.*

Quod si acciderit  $Q^2$  æquale esse dimidio quadrati ex  $R$ ; evanescente quantitate  $2 Q^2 - RR = 0$ , quarta proportionalis  $PF$  fit infinita: proinde Trajectoria describenda Parabolica est, Foco scilicet altero in infinitum abeunte. Axis autem Trajectoriæ positione datur; est enim ipsi  $PF$  parallelus, existente scilicet angulo  $FPP$  angulo dato  $SPT$  æquali.

*Coroll. 3. Velocitas revolvantis in data Sectione Conica ad distantiam  $SP$  est ad Velocitatem ejusdem ad distantiam aliquam  $SX$ , ut media proportionalis inter  $FP$  &  $SX$  ad mediam proportionalem inter  $SP$  &  $FX$ .* Velo-



Velocitas enim in  $P$  est ut  $\sqrt{\frac{FP}{SP}}$  (per propr. II.) & per eandem, Velocitas in  $X$  est ut  $\sqrt{\frac{FX}{SX}}$ . Unde manifesta est propositio.

Coroll. 4. *Ratio etiam Velocitatum duorum Corporum in eodem Systemate, sed in datis Confectionibus diversis, revolventium, datis utriusque à communi Orbium Foco distantis, ope Corollarii 1<sup>mi</sup>. statim obtinebitur.*

Cum enim Velocitas corporis in  $P$  sit ad Velocitatem in Circulo ad eandem distantiam  $SP$ , ut  $\sqrt{PF}$  ad  $\sqrt{CD}$ ; & in alia supposita Confectione, cujus Semiaxis  $cd$  & Foci  $S, f$ , ad distantiam  $Sp$  Velocitates illæ sint ut  $\sqrt{pf}$  ad  $\sqrt{cd}$ : Velocitas autem revolventis in circulo ad distantiam  $SP$  sit ad Velocitatem in Circulo ad distantiam  $Sp$  ut  $\sqrt{Sp}$  ad  $\sqrt{SP}$ ; Compositis rationibus, erit Velocitas in  $P$  ad Velocitatem in  $p$ , ut  $\sqrt{PF} \times cd \times Sp$  ad  $\sqrt{pf} \times CD \times SP$ . Quod si Sectio illa altera fuerit Parabola, erunt  $cd, pf$  infinitæ, sed in ratione 1 ad 2; proinde ratio Velocitatum erit ut  $\sqrt{PF} \times Sp$  ad  $\sqrt{2CD \times SP}$ .

Coroll. 5. *Quod si in Hyperbola punctum  $P$  abeat in infinitum, ex præcedentibus manifestum est, Velocitatem ultimam ac minimam, qua cum corpus in æternum ascenderet, æqualem esse ei qua, ad distantiam  $CD$  Semiaxi transverso æqualem, Circulum describeret.*

Coroll. 6. *Ex data distantia à Foco, datur quoque Positio Tangentis, sive angulus  $SPT$ , sub distantia  $SP$  & Tangente  $PT$  contentus.*

Est enim (per propr. II.)  $PS$  ad  $ST$  ut  $CK$  ad  $CO$  sive ut  $\sqrt{SP} \times PF$  ad  $CO$ , atque ita Radius ad Sinum anguli  $SPT$ . At in Ellipsis Circulis præstaret angulum  $PST$ , ejusdem complementum ad quadrantem, inquirere: Hujus autem Sinus est ad Radium ut  $\sqrt{SP} \times PF - CO$  q ad  $\sqrt{SP} \times PF$ .

Coroll.

*Coroll. 7. Atque hinc consequuntur Velocitates quibuscum distantia  $SP$  crescunt vel decrescunt.*

Nam cum, ex Corollario præcedente,  $\sqrt{SP \times PF}$  sit ad  $\sqrt{SP \times PF - CO}q$  ut Radius ad sinum anguli  $PST$ , ac in eadem sit ratione Velocitas Corporis in  $P$  ad Velocitatem momenti ipsius  $SP$ ; Velocitas autem illa in  $P$  sit (per propr. II.) ut  $\sqrt{\frac{PF}{SP}}$ ; elisis superfluis, erit  $\sqrt{\frac{SP \times PF - CO}{SP}q}$  Velocitati, qua crescit vel decrescit distantia  $SP$ , semper proportionalis.

## THEOREMA GENERALE II.

*In omni Trajectoria Curvilinea Velocitates angulares circa centrum Virium sunt reciproce proportionales quadratis distantiarum à centro.*

Nam ob Sectorum minimorum Areas æquales, arcus angulis minimis subtensi sive Bases, sunt reciproce ut Radii: Anguli autem minimi quibus Bases æquales subtenduntur sunt etiam reciproce ut Radii. Proinde anguli Sectorum minimorum Area æqualium, sunt inter se reciproce in dupla ratione Radiorum, sive ut quadrata distantiarum.

*Coroll. 8. Hinc Velocitates angulares revolvantium in diversis Ellipsis datis comparantur inter se.*

Velocitates enim angulares quibuscum ad distantias Semiaxibus Transversis æquales circuli describerentur, sunt reciproce in ratione sesquialtera Axium, sive ut  $\frac{1}{CD\sqrt{CD}}$ .

Velocitates autem angulares has medias habent Corpora revolvantia, cum quadrata distantiarum æquantur rectangulis sub semiaxibus Ellipseôn. Ideo (per Theor. II.) erit  $SPq$  ad  $CD \times CO$  ut  $\frac{1}{CD\sqrt{CD}}$  ad  $\frac{CO}{SPq \times \sqrt{CD}}$ : quæ quidem Quantitas est ut Velocitas anguli ad centrum  $S$ , motu rectæ  $SP$ , tempore quam minimo dato, descripti.

*Coroll. 9. Velocitas angularis qua circumgyratur Tangens  $PT$ , sive recta in Tangentem perpendicularis  $ST$ , est ad Velocitatem*

*locitatem angularem rectæ SP, ut Semiaxis transversus CD ad distantiam ab altero Foco PF.*

*Demonstratio.*

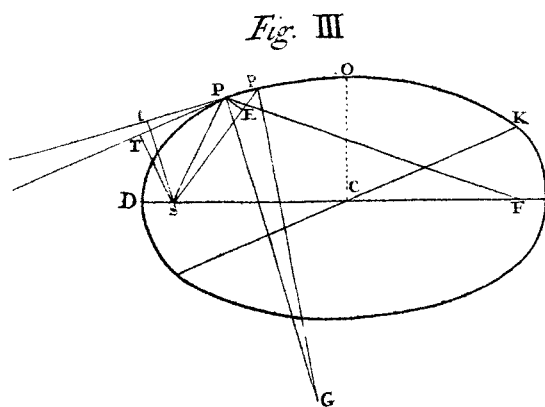
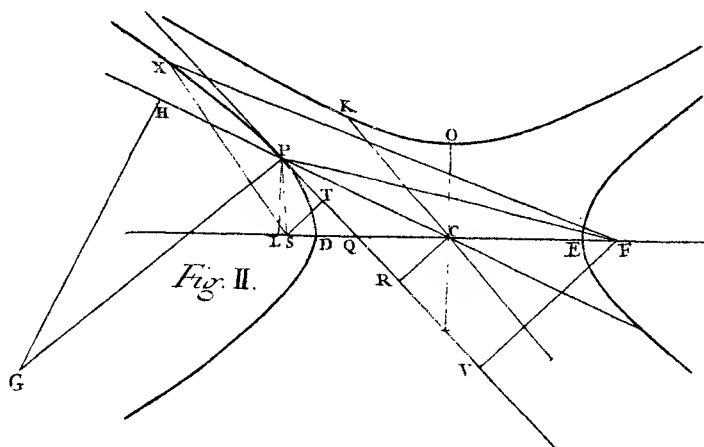
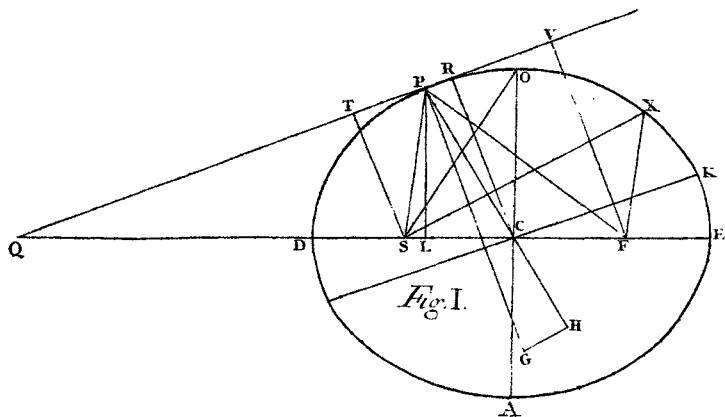
In Fig. III. Sint puncta  $P, p$ , quamproxima inter se; ductisque  $SP, Sp$ , sint  $PT, pt$  duæ Tangentes, ad quas demittantur normales  $ST, St$ ; iisque parallelæ ducantur radii Curvaturæ  $PG, pG$  coeuntes in  $G$ : ac describatur, centro  $S$  & radio  $SP$ , arcus minimus  $PE$  occurrens ipsi  $Sp$  in  $E$ . Manifestum est angulum  $PGp$  æqualem esse angulo  $TSt$ , sive angulari Velocitati normalis  $ST$ . Est autem angulus  $PSp$  angularis velocitas rectæ  $SP$ ; quare angulus  $PGp$  est ad angulum  $PSp$  ut angularis Velocitas ipsius  $ST$  ad angularem velocitatem rectæ  $SP$ ; hoc est, ut  $\frac{Pp}{PG}$  ad  $\frac{PE}{PS}$ . Sed  $Pp \cdot PE :: SP \cdot ST :: CK : CO$

(per propr. II). Hæ igitur Velocitates sunt ut  $\frac{CK}{PG}$  ad  $\frac{CO}{PS}$ .

Pro  $PG$  scribe  $\frac{CK^3}{CD \times CO}$  (per propr. V.) ac  $\frac{CK}{PG}$  fiet  $\frac{CD \times CO}{CKq} = \frac{CD \times CO}{PS \times PF}$ . Hinc  $\frac{CD \times CO}{PS \times PF}$  erit ad  $\frac{CO}{PS}$ , sive, deletis superfluis,  $CD$  ad  $PF$ , ut angulus  $TSt$  ad angulum  $PSp$ , sive Velocitas angularis Tangentis ad angularem Velocitatem distantiae  $SP$ : proinde Velocitas qua circumgyratur Tangens, semper proportionalis est quantitati  $\frac{CO \times \sqrt{CD}}{PF \times SPq}$ .

*Pleraque horum Corollariorum ex aliis Conicarum Sectionum Proprietatibus deducta, vel facile deducenda, inveniet Lector in Sect. III. Lib. I. Princip. Nat. Philosophiæ.*

*F I N I S.*



# PHILOSOPHICAL TRANSACTIONS.

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For the Months of *July, August, and Sep.* 1717.

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I. **A**N *Account of a Dissection of a Child, Communicated in a Letter to Dr. Brook Taylor, R. S. Sec. By Dr. Patrick Blair, R. S. S.*

II. *De Seriebus infinitis Tractatus. Pars Prima. Auctore Petro Remundo de Monmort. R. S. S. Una cum Appendice & Additamento per D. Brook Taylor, R. S. Sec.*

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D d d d d

I. An

I. *An Account of the Dissection of a Child. Communicated in a Letter to Dr. Brook Taylor, R. S. Secr. By Dr. Patrick Blair, R. S. S.*

As nothing is more apt to lead us to the Knowledge of the several Distempers which affect the Human Body, and to acquaint us with the just Prognosticks of the like Cases, than the opening of distemper'd Persons. I hop'd it would not be an unacceptable instance of my Zeal and Readiness to serve the Most Honourable the *Royal Society* upon all occasions, to desire you to present them with the following account of the Dissection I lately made of a Child.

This Child was five Months old, and was so emaciated, that he appear'd rather to have decreased, than to have encreased in Bulk, from the time of his Birth; his whole Body not weighing above five Pounds. The Skin and Muscles of the Abdomen were very thin, but the Peritoneum was preternaturally thick. The Ventriculus was more like to an Intestine than to a Stomach, its length being five Inches, and its breadth but one Inch. The Coats of it were thick and fleshy, and the Cavity very inconsiderable. The Pylorus, and almost half of the Duodenum were Cartilaginous, and something inclin'd to an Ossification; so that no Nourishment could have passed into the Intestines, tho' the Stomach had been capable of containing it, which makes it no Wonder that the Body was so emaciated. There were scarce any foot-steps of the Omentum to be seen, even at the Bottom of the Stomach, to which it usually adheres.

The

The right Lobe of the Lungs adhered firmly to the Ribs and had three Exulcerations, which contain'd purulent Matter. It was so very thin and compact, that it seem'd as if that Lobe had never been of use in Respiration. The left Lobe was of a more florid Red, spongy, and free from any Adhesion.

Upon enquiring after the Symptoms this Child had been affected with, his Mother told me, he seem'd to be healthy till he was about a Month old, when he was seized with a violent Vomiting, and a Stoppage of Urine and Stool. Some time after, both these became more regular, but the Vomiting still continued. He seem'd to have a great Appetite, taking what Suck, Drink, or other Food was offer'd him, with a kind of eagerness; but he immediately threw it all up again. He had all along breathed freely, and had no Cough, notwithstanding the Exulcerations above mention'd. This confirm'd me in the Opinion that he had never Breath'd, by the right Lobe of the Lungs.

There could be nothing more emaciated than this Child was; and it seems to be worth considering, whether his Illness might not be owing in a great measure to the want of the Omentum, (for he seem'd never to have had any); as also, whence it is that this Part is generally consum'd in an Atrophy, and in most Hydropical Cases, except where it self is more especially concerned.

II. De Seriebus infinitis Tractatus. Pars Prima.  
Auctore Petro Remundo de Monmort. R. S. S.

Prop. 1. Prob.

**I**Nvenire summam terminorum quot libuerit Seriei  
hujus  $a \times a + n \times a + 2n \times \&c. \times a + p - 1n$   
 $+ a + n \times a + 2n \times a + 3n \times \&c. \times a + pn$   
 $+ a + 2n \times a + 3n \times a + 4n \times \&c. \times a + p + 1n$   
 $+ a + 3n \times \&c.$  Ubi est  $n$  differentia data, tam inter  
Factores continuos,  $a, a + n, a + 2n, \&c.$  ejusdem cu-  
jusvis termini, quàm inter Factores homologos termino-  
rum diversorum in Serie continuatâ; atque designat  $p$  nu-  
merum factorum hujusmodi in quovis termino.

*Solutio* Per  $x$  designetur primus Factorum in ultimo ter-  
minorum quorum summa requiritur, atque summa illa erit  
$$\frac{x \times x + n \times \&c. \times x + pn - a - n \times a \times \&c. \times a + p - 1n}{p + 1n}$$

*Q. E. I.*

*Ex. 1.* Proponatur Series numerorum naturalium  
 $1 + 2 + 3 + 4 + \&c.$  & invenienda sit summa tot  
terminorum quot sunt unitates in numero  $z$ , qui in hoc  
casu est etiam ultimus terminorum quorum summa requiri-  
tur. In hoc itaque casu sunt  $a = 1, n = 1, p = 1, \&c.$   
 $x = z.$  Unde fit  $x \times x + n \times \&c. \times x + pn = z \times z + 1,$   
 $a - n \times a \times \&c. \times a + p - 1n = 0 \times 1,$  atque  $p + 1n$   
 $= 2 \times 1;$  adeoque summa quæsitæ est  $\frac{z \times z + 1}{2}.$

*Ex. 2.* Invenienda sit summa tot terminorum, quot  
sunt unitates in numero  $z$ , Seriei  $1 + 3 + 6 + 10 + \&c.$   
Numerorum Triangularium. Numeri  $1, 3, 6, 10, \&c.$  in hac  
E e e e c Serie



Serie sic scribi possunt  $\frac{1 \times 2}{2}, \frac{2 \times 3}{2}, \frac{3 \times 4}{2}, \frac{4 \times 5}{2}, \&c.$

Hoc pacto, seposito divisore dato 2, Series revocatur ad formam Propositionis, existentibus  $a = 1, n = 1, \& p = 2. x = z$  Unde summa Seriei duplicata est  $\frac{x \times x + 1 \times x + 2 - 0 \times 1 \times 2}{3} = \frac{x \times x + 1 \times x + 2}{3}$ ;

adeoque habitâ ratione divisoris 2, Summa Seriei ipsius est  $\frac{x \times x + 1 \times x + 2}{2 \times 3}$ , vel  $\frac{z \times z + 1 \times z + 2}{2 \times 3}$ , in hoc casu

existente  $x$  eodem ac  $z$ . Ad eundem modum inveniuntur summae cæterorum numerorum figuratorum, quorum formulæ jam vulgò innotescunt.

Ex. 3. Sint  $a = 1, n = 2, p = 3$ . ut sit Series proposita  $1 \times 3 \times 5 + 3 \times 5 \times 7 + 5 \times 7 \times 9 + \&c.$  In hoc itaque casu formula summæ fit

$$\frac{x \times x + 2 \times x + 4 \times x + 6 - 1 - 2 \times 1 \times 3 \times 5}{\frac{4 \times 2}{8}} = \frac{x \times x + 2 \times x + 4 \times x + 6 + 15}{8}.$$

Verbi gratiâ, si quaratur summa decem terminorum, sit  $x = 19$  (nempe terminus decimus in Serie Arithmeticè proportionalium, 1, 3, 5, 7, &c.) adeoque summa est  $\frac{19 \times 21 \times 23 \times 25 + 15}{8} = 28680$ . Propositio vero sic demonstratur.

*Demonstratio.* Sit Series quantitatum  $A, B, C, D, E, \&c.$  quarum differentiæ constituent Seriem  $a, b, c, d, \&c.$  (nempe ut sint  $a = B - A, b = C - B, c = D - C, \&c.$ ) Hinc statim colligitur esse  $a + b = C - A, a + b + c = D - A, a + b + c + d = E - A$ : & in genere aggregatum quolibet terminorum Seriei  $a, b, c, d, \&c.$  æquale est termino proximè insequenti Seriei  $A, B, C, D, E, \&c.$  mulato termino primo  $A$ . Pro  $A, B, C, \&c.$  sume terminos

$$\frac{a - n \times a \times \mathcal{C}c. \times a + p - 1n}{p + 1n}, \frac{a \times a + n \times \mathcal{C}c. \times a + pn}{p + 1n}$$

$$\frac{a + n \times a - 2n \times \mathcal{C}c. \times a + p - 1n}{p + 1n}, \mathcal{C}c. \text{ hoc est, valo-}$$

res successivos ipsius  $\frac{x \times x + n \times \mathcal{C}c. \times x - pn}{p + 1n}$ ; & co-

rum differentia, pro  $a, b, c, d, \mathcal{C}c.$  sumenda, erunt  $a \times a + n \times \mathcal{C}c. \times a + p - 1n, a + n \times a + 2n \times \mathcal{C}c. \times a + pn, \mathcal{C}c.$  qui sunt ipsissimi termini Series propositae. Sed comparando has Series, si terminus aliquis Series posterioris sit  $x \times x + n \times \mathcal{C}c. \times x + p - 1n$ , constat terminum uno ulteriorem in Serie priori fore

$$\frac{x \times x + n \times \mathcal{C}c. \times x + pn}{p + 1n}. \text{ Summa itaque Series poste-}$$

rioris usque terminum  $x \times x + n \times \mathcal{C}c. \times x + p - 1n$  inclusivè est  $\frac{x \times x + n \times \mathcal{C}c. \times x + pn - a - n \times a \times \mathcal{C}c. \times a + p - 1n}{p + 1n}$

Q. E. D.

*Scholium 1.* In hac propositione continetur particula quaedam Methodi incrementorum, de qua ante biennium librum edidit D. Brook Tayler Soc. Reg. Lond. Secr. mihi amicitia conjunctissimus. Librum ipsum adeat qui de eâ methodo plura scire velit: ad institutum nostrum sufficit observare quanta intersit affinitas inter Methodum hanc & Methodum Fluxionum seu differentialem Nam ut in Methodo differentiali, ad inveniendum differentiale ipsius  $x$  dignitatis  $x^m$ , unum latus  $x$  convertendum est in differentiam  $dx$ ; & ortum ducendum est in dignitatis Indicem  $m$ , ut sit  $m dx x^{m-1}$  differentiale quaesitum; sic in Methodo Incrementorum *Ad inveniendum Incrementum facti hujusmodi*  $x \times x + n \times x + 2n, \text{ (ubi factores } x, x + n, x + 2n,$

$x + 2n$ , sunt in progressionē Arithmetica, cujus differentia communis est ipsius  $x$  Incrementum datum  $n$ .) Factorum minimus  $x$  convertendus est in Incrementum, & ortum ducendum est in numerum Factorum, ut sit  $3n \times x + n \times x + 2n$  Incrementum quæsitum, numero Factorum in casu exposito existente 3. Sic etiam ipsius  $x \times x + n$  Incrementum fit  $2n \times x + n$ .

2. Incrementa etiam Reciprocorum hujusmodi Factorum inveniuntur per eandem regulam; hoc nempe observato, quòd cum sit Divisio contrarium Multiplicationis, vice ablationis minimi Factorum, sit jam addendus alius factor adhuc uno Incremento major; item quòd Factorum numerus sit scribendus cum signo negativo.

Hoc pacto ipsius  $\frac{1}{x}$  Incrementum fit  $\frac{-1 \times n}{x \times x + n}$ ; ipsius

$\frac{1}{x \times x + n}$  Incrementum fit  $\frac{-2 \times n}{x \times x + n \times x + 2n}$ ; & sic

de aliis hujusmodi. Hoc facile probatur sumendo differentias inter Integralium valores duos continuos.

3. Insistendo vestigiis Methodi directæ, hinc colliguntur præcepta Methodi inversæ, quibus inveniuntur Integralia Incrementorum oblatorum. Applicetur enim Incrementum oblatum ad lateris Incrementum datum; addatur Factor adhuc uno Incremento minor, & applicetur ortum ad numerum Factorum sic auctorum. Sic e. g. oblato Incremento  $\frac{n \times x \times x + n \times x + 2n}{x \times x + 2n}$ , fit primò  $\frac{x \times x + n}{x \times x + 2n}$ ; deinde  $x - \frac{n \times x \times x + n \times x + 2n}{x \times x + 2n}$ , addito Factore  $x - n$ ; denique  $\frac{x - n \times x \times x + n \times x + 2n}{x \times x + 2n}$ , quod

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est Integræle quæsitum. Hoc quidem ubi Factores sunt Multiplicantes; Ubi vero Factores occupant locum divisoris, mutatis mutandis, regula hæc est, Applicetur Incrementum oblatum ad lateris incrementum datum; rejiciatur Factorum

*Factorum maximus, & applicetur ortum ad numerum Factorum relictorum cum signo negativo. Exempli gratiâ oblato Incremento*  $\frac{n}{x \times x + n \times x + 2n}$ , *fit primò*

$$\frac{\frac{1}{x \times x + n \times x + 2n}}{\frac{1}{x \times x + n}}, \text{ deinde } \frac{1}{x \times x + n}, \text{ denique}$$

$$\frac{1}{-2 \times x \times x + n}, \text{ seu } \frac{-1}{2x \times x + n}, \text{ quod est Integrale quæsitum.}$$

4. In casu hoc novissimo Integrale inventum, cum signo contrario, æquale est summæ omnium Incrementorum in Serie in infinitum continuatâ; *v. g.* est  $\frac{1}{2x \times x + n}$

$$= \frac{n}{x \times x + n \times x + 2n} + \frac{n}{x + n \times x + 2n \times x + 3n} + \frac{n}{x + 2n \times x + 3n \times x + 4n} + \&c. \text{ Nam in hoc ca-}$$

su, facto  $x$  tandem infinito, evanescit  $\frac{1}{2x \times x + n}$ , hoc est, ultimus terminorum  $A, B, C; \&c.$  fit nihil; & ob contrarietatem signorum Integralis & Incrementi, vice  $-A$  exprimitur aggregatum per  $+A$ .

### Lemma I.

Per  $X$  designetur terminus quilibet in Serie quâvis numerorum  $M, N, O, P, \&c.$ ; per  $x$  designetur locus termini istius  $X$  in Serie illâ (*v. g.* ut sit  $x = 1$ , quando designat  $X$  terminum primum  $M$ , sit  $x = 2$ , quando designat  $X$  terminum secundum  $N$ , & sic de cæteris) & sint terminorum  $M, N, O, P$  prima differentiarum primarum  $b, c$  prima differentiarum secundarum,  $d$  prima tertiarum,  $e$  prima quartarum, & sic porro. Tum erit

$$F f f f f \quad X = M$$

$$\begin{aligned}
 X = & M + b \times \frac{x-1}{1} + c \times \frac{x-1}{1} \times \frac{x-2}{2} + d \times \frac{x-1}{1} \\
 & \times \frac{x-2}{2} \times \frac{x-3}{3} + e \times \frac{x-1}{1} \times \frac{x-2}{2} \times \frac{x-3}{3} \times \\
 & \frac{x-4}{4} + \& c. \text{ Sequitur hoc ex tabulâ æquationum pag.} \\
 & 66. tractatûs nostri *Essay d'Analyse, & c.*
\end{aligned}$$

*Lemma 2.*

Isdem positis, per  $z$  designetur terminus quilibet in Serie Arithmeticè proportionalium  $a, a + n, a + 2n, \& c.$  & sit jam  $X = A + Bz + Cz \times z + n + Dz \times z + n \times z + 2n + Ez \times z + n \times z + 2n \times z + 3n + \& c.$  Tum ipsorum  $A, B, C, D, E, \& c.$  valores erunt.

$$\begin{aligned}
 A = & M + b \times \frac{-a}{n} + c \times \frac{-a}{n} \times \frac{-a-n}{2n} + \\
 & + d \times \frac{-a}{n} \times \frac{-a-n}{2n} \times \frac{-a-2n}{3n} + \\
 & + e \times \frac{-a}{n} \times \frac{-a-n}{2n} \times \frac{-a-2n}{3n} \times \frac{-a-3n}{4n} + \& c. \\
 B = & \frac{1}{n} \times b + c \times \frac{-a-n}{n} + d \times \frac{-a-n}{n} \times \frac{-a-2n}{2n} \\
 & + e \times \frac{-a-n}{n} \times \frac{-a-2n}{2n} \times \frac{-a-3n}{3n} \& c. \\
 C = & \frac{1}{n} \times \frac{1}{2n} \times c + d \times \frac{-a-2n}{n} + e \times \frac{-a-2n}{n} \times \frac{-a-3n}{2n} + \& c. \\
 D = & \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} d + e \times \frac{-a-3n}{n} + \& c. \\
 E = & \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times \frac{1}{4n} e + \& c.
 \end{aligned}$$

Ordo

Ordo formandi coefficientes ipsorum  $b, c, d, e, \&c.$  in his valoribus, per se est satis manifestus.

*Demonstratio.* Quoniam per  $x$  &  $z$  designantur termini correspondentes progressionum Arithmeticarum  $1, 2, 3, 4, \&c.$  &  $a, a + n, a + 2n, a + 3n, \&c.$  indicabit  $x - 1$  numerum differentiarum  $n$  qui in  $z$  continetur, ut sit

$$z = a + \overline{x - 1 n}. \quad \text{Hinc fit } x - 1 = \frac{z - a}{n}, \quad x - 2 = \frac{z - n - a}{n}, \quad x - 3 = \frac{z - 2n - a}{n}, \&c.$$

Substituendo itaque hos valores  $x - 1, x - 2, x - 3, \&c.$  in Serie Lemmatis præcedentis, & termi is in ordinem redactis, prodeunt ipsorum  $A, B, C, \&c.$  valores exhibit.

*Cor.* Ubi  $a = n$ , prodeunt  $A, B, C, D, \&c.$  per formulas simpliciores, nempe

$$A = M - b + c - d + e \&c.$$

$$B = \frac{1}{n} \times \overline{b - 2c + 3d - 4e \&c.}$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times \overline{c - 3d + 6e \&c.}$$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times \overline{d + 4e \&c.}$$

### Lemma 3.

Symbolis  $X$  &  $x$  eodem modo interpretatis ac in Lemmate primo, sint  $q, r, s, t, u, \&c.$  generatores Trianguli Arithmetici cujus lineam transversam, occupat Series  $M, N, O, P, Q, \&c.$  in ordine nempe inverso, ut sit  $q (= M)$  generator ultimus,  $r$  penultimus,  $s$  antepenultimus, & sic porro. Tum erit

$$X = q + r \times \frac{x-1}{1} + s \times \frac{x-1}{1} \times \frac{x}{2} + t \times \frac{x-1}{1} \times \frac{x}{2} \times \frac{x+1}{3} + \&c.$$

Constat

Constat ex contemplatione ipsius Trianguli Arithmetici, quam exhibuimus *pag.* 63 tractatus *Essay d'Analyse, &c.* ubi idem fusius explicatur.

*Lemma 4.*

Iisdem positis, & Symbolo  $z$  eodem modo interpretato ac in *Lem.* 2. si sit  $X = A + Bz + Cz \times z + n + \&c.$  ut in *Lem.* 2. erunt coefficientium  $A, B, C, D, \&c.$  valores.

$$A = q + r \times \frac{-a}{n} + s \times \frac{-a}{n} \times \frac{-a + n}{2n} \\ + t \times \frac{-a}{n} \times \frac{-a + n}{2n} \times \frac{-a + 2n}{3n} + \&c.$$

$$B = \frac{1}{n} \times r + s \times \frac{-a}{n} + t \times \frac{-a}{a} \times \frac{-a + n}{2n} + \&c.$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times s + t \times \frac{-a}{n} + \&c.$$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times t + \&c.$$

Ordo coefficientium in his valoribus est manifestus, & demonstratur Lemma ad modum *Lemmatum* 2.

*Cor. 1.* Ubi  $a = n$ , coefficientes,  $A, B, C, D, \&c.$  prodeunt per formulas simpliciores, nempe

$$A = q - r, \quad C = \frac{1}{n} \times \frac{1}{2n} \times s - t \quad \&c. \\ B = \frac{1}{n} \times r - s, \quad D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} t - u$$

*Cor. 2.* Unde si generatorum  $q, r, s, t, u, \&c.$  aliquot sint inter se æquales, exhibebitur  $X$  per formulam simpliciore, evanescentibus aliquot coefficientium  $A, B, C, D, \&c.$

Sic





videatur vel differentias, vel generatores trianguli Arithmetici adhibere,) resolvatur  $X$  in Multinomium  $A + B \times z + C z \times z + n + D z \times z + n \times z + 2n + \text{etc.}$  Hoc pacto (terminis multinomii ad denominatorem  $z \times z + n \times \text{etc.} \times z + p - n$ , applicatis) terminus quilibet Seriei

$$\text{revocabitur ad formulam } \frac{A}{z \times z + n \times \text{etc.} \times z + p - 1n} + \frac{B}{z + n \times \text{etc.} \times z + p - 1n} + \frac{C}{z + 2n \times \text{etc.} \times z + p - 1n} + \text{etc.}$$

Unde (per Scholium 4 Prop. I.) aggregatum totius Seriei, à termino  $\frac{X}{z \times z + n \times \text{etc.} \times z + p - 1n}$  inclusi, ve. in infinitum continuata, est

$$\frac{A}{p - 1 \times n \times z \times z + n \times \text{etc.} \times z + p - 2n} + \frac{B}{p - 2 \times n \times z + n \times \text{etc.} \times z + p - 2n} + \frac{C}{p - 3 \times n \times z + 2n \times \text{etc.} \times z + p - 2n} + \text{etc.}$$

re si dematur hoc aggregatum ab ejusdem aggregati valore quando  $z = a$ , residuum erit summa omnium terminorum ante terminum  $\frac{X}{z + \text{etc.}}$ , hoc est, tot terminorum quot sunt unitates in  $\frac{z - a}{n}$ . Q E I.

Ex. 1. Sit primum exemplum in Serie  $\frac{5}{3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13}$

( 643 )

$$\begin{aligned}
 &+ \frac{41}{5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15} + \frac{131}{7 \cdot 9 \cdot 11 \cdot 13 \cdot 15 \cdot 17} \\
 &+ \frac{275}{9 \cdot 11 \cdot 13 \cdot 15 \cdot 17 \cdot 19} + \frac{473}{11 \cdot 13 \cdot 15 \cdot 17 \cdot 19 \cdot 21} \\
 &+ \text{Ec. Sunthic } a=3, n=2, v=5, M=5, \& \text{ capi-} \\
 &\text{piendo differentias numeratorum inveniuntur } b=36, \\
 &c=54, d=0=e=\text{Ec. Hinc in Lemmate secun-} \\
 &\text{do sunt } A=5 + 36 \times \frac{-3}{2} + 54 \times \frac{-3}{2} \times \frac{-5}{4} = \frac{209}{4}, \\
 &B = \frac{1}{2} \times 36 + 54 \times \frac{-5}{2} = \frac{-99}{2}, C = \frac{1}{2} \times \frac{1}{4} \times 54 \\
 &= \frac{27}{4}, D=0=E=\text{Ec. Summa itaque totius Seriei}
 \end{aligned}$$

$$\begin{aligned}
 &\text{est } \frac{209}{4 \times 5 \times 2 \times 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11} + \frac{-99}{2 \times 4 \times 2 \times 5 \cdot 7 \cdot 9 \cdot 11} \\
 &+ \frac{27}{4 \times 3 \times 2 \times 7 \cdot 9 \cdot 11} = \frac{283}{80 \times 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11}, \text{ atque} \\
 &\text{summa terminorum numero } \frac{z-3}{2} \left( = \frac{z-a}{n} \right) \text{ est}
 \end{aligned}$$

$$\begin{aligned}
 &\frac{283}{80 \times 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11} - \frac{209}{40 \times z \cdot z + 2 \cdot z + 4 \cdot z + 6 \cdot z + 8} \\
 &+ \frac{99}{16 \times z + 2 \times z + 4 \cdot z + 6 \cdot z + 8} - \frac{27}{24 \times z + 4 \cdot z + 6 \cdot z + 8}
 \end{aligned}$$

$$\begin{aligned}
 &\text{Querantur v. g. octo termini; tum existente } \frac{z-3}{2} = \\
 &8 \text{ fit } z=19, \text{ quo valore in formulâ adhibito, prodit} \\
 &\text{summa } \frac{155891}{2 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 5 \cdot 5 \cdot 5 \cdot 7 \cdot 11 \cdot 19 \cdot 23}
 \end{aligned}$$

Iidem Numeratores occupant lineam tertiam transversam in Triangulo Arithmetico

$$\begin{aligned}
 &54 \cdot 54 \cdot 54 \cdot 54 \cdot 54 \cdot 54 \cdot \text{Ec.} \\
 &= 18 \cdot 36 \cdot 90 \cdot 144 \cdot 198 \cdot \text{Ec.} \\
 &5 \cdot 41 \cdot 131 \cdot 275 \cdot \text{Ec.}
 \end{aligned}$$

Unde

( 644 )

Unde in formula *Lem. 4.* sunt generatores  $q = 5$ ,  
 $r = -18$ ;  $s = 54$ ,  $t = 0 = \&c.$  & prodeunt coeffi-

$$\text{cientes } A = 5 - 18 \times \frac{-3}{2} + 54 \times \frac{-3}{2} \times \frac{-3}{4} =$$

$$\frac{209}{4}, B = \frac{1}{2} \times -18 + 54 \times \frac{-3}{2} = \frac{-99}{2}, C = \frac{1}{2}$$

$$\times \frac{1}{4} \times 54 = \frac{27}{4}, D = 0 = E = \&c. \text{ iidem ac supra.}$$

*Ex. 2.* Sit Series  $\frac{4}{1.2.3.4.5.6.7.8.9.10.11}$

$$+ \frac{69}{2.3.\&c.12} + \frac{530}{3.4.\&c.13} + \frac{2676}{4.5.\&c.14} +$$

$$\frac{10350}{5.6.\&c.15} + \&c. \text{ Ubi sunt } a = 1, n = 1, p = 11,$$

atque Numeratores constituent Seriem in *Corol. 20. Lem. 4.*  
 exhibitam. Applicando itaque valorem  $X$  in *Corol. illo*  
 ad denominatorem  $z \times z + 1 \times \&c. \times z + 10$ , fit Seriei  
 propositæ Terminus

$$\frac{-1}{1.2.3.4.5.6 \times z + 6.z + 7.z + 8.z + 9.z + 10}$$

$$+ \frac{23}{1.2.3.4.5.6.7 \times z + 7.z + 8.z + 9.z + 10}$$

$$- \frac{72}{1.2.3.4.5.6.7.8 \times z + 8.z + 9.z + 10}$$

$$+ \frac{54}{1.2.3.4.5.6.7.8.9 \times z + 9 \times z + 10}.$$

Adeoque  
 per hanc *Prop.* summa Seriei à termino illo in infinitum  
 continuatæ est

$$\frac{-1}{4 \times 1.2.3.4.5.6 \times z + 6.z + 7.z + 8.z + 9} +$$



proposita. Tum (quod ex contemplatione Trianguli Arithmetici facile constat) sunt

$$a = t$$

$$b = \frac{p-1}{1} t + u$$

$$c = \frac{p-1}{1} \times \frac{p-2}{2} t + \frac{p-2}{1} u + x$$

$$d = \frac{p-1}{1} \times \frac{p-2}{2} \times \frac{p-3}{3} t + \frac{p-2}{1} \times \frac{p-3}{2} u \\ + \frac{p-3}{1} x + y \&c.$$

Unde colliguntur generatorum valores

$$t = a$$

$$u = b - \frac{p-1}{1} t$$

$$x = c - \frac{p-1}{1} \times \frac{p-2}{2} t - \frac{p-2}{1} u$$

$$y = d - \frac{p-1}{1} \times \frac{p-2}{2} \times \frac{p-3}{3} t - \frac{p-2}{1} \times \frac{p-3}{2} u \\ - \frac{p-3}{1} x \&c.$$

Ultimus autem generator æqualis est Seriei termino primo  $\omega$ .

2. D<sup>nus</sup> de *Monfory Abbas Orbacensis* mihi amicissimus, & ruri vicinus, postquam cum eo hæc communicaveram, aliam invenit hujus Problematis Solutionem, cujus formulam ob ejus miram simplicitatem hic referre juvat. Itaque in Serie numeratorum sint  $\omega$  terminus primus,  $b$  prima differentiarum primarum,  $c$  prima secundarum,  $d$  prima tertiarum, & sic porro; atque sit termini primi Denominator  $z \times z + n \times \&c. \times z + p - 1 n$ ; Tum  
summa

summa totius Seriei in infinitum continuatæ exhibebitur

$$\text{per formulam } \frac{\omega}{n \times p - 1 \times z \times z + n \times \textcircled{c} \times z + p - 2n} + \frac{b}{n^2 \times p - 1 \times p - 2 \times z + n \times \textcircled{c} \times z + p - 2n} + \frac{c}{n^3 \times p - 1 \times p - 2 \times p - 3 \times z + 2n \times \textcircled{c} \times z + p - 2n} + \textcircled{c}.$$

Sit exemplum in Serie  $\frac{5}{3 \cdot 5 \cdot \textcircled{c} \cdot 13} + \frac{41}{5 \cdot 7 \cdot \textcircled{c} \cdot 15} + \frac{131}{7 \cdot 9 \cdot \textcircled{c} \cdot 17} + \frac{275}{9 \cdot 11 \cdot \textcircled{c} \cdot 19} + \textcircled{c}$  .cujus summam jam exhibuimus. In hoc casu sunt  $\omega = 5$ ,  $b = 36$ ,  $c = 54$ ,  $d = 0 = e = \textcircled{c}$ . Unde per formulam summa Seriei integræ fit  $\frac{5}{2 \cdot 5 \times 3 \cdot 5 \dots 11} + \frac{36}{4 \cdot 5 \cdot 4 \times 5 \dots 11}$

$+ \frac{54}{8 \cdot 5 \cdot 4 \cdot 3 \times 7 \dots 11} = \frac{283}{80 \times 3 \cdot 5 \dots 11}$ , ut per formulam nostram exhibetur. Si quæritur summa ejusdem Seriei incipientis à termino decimo  $\frac{2273}{21 \dots 31}$ , in

eo casu  $\omega = 2273$ ,  $b = 522$ ,  $c = 54$ , & summa esset  $\frac{2273}{2 \cdot 5 \times 21 \dots 29} + \frac{522}{4 \cdot 5 \cdot 4 \times 23 \dots 29} + \frac{54}{8 \cdot 5 \cdot 4 \cdot 3 \times 25 \dots 29}$

Hæc formula est commodissima, & summam exhibet nullo ferè negotio, quoties quæritur summa Seriei integræ, & differentiæ non sunt nimis multæ. Sed ubi plures sunt differentiæ, & quæritur non Series integra, sed termini tantum initiales aliquammulti, formulæ nostræ sunt commodiores.

3. Quando

3. Quando Serierum termini formantur tantum per Multiplicationem, nec afficiuntur divisoribus variabilibus, summæ semper exhiberi possunt per Methodum in *Prop. I.* traditam, sint licet formulæ quantumlibet compositæ. Nam possunt semper revocari ad terminos in formâ quam postulat Propositio illa. Sic si differentiæ ipsorum  $z$  &  $x$  sint  $m$  &  $n$ , & designetur terminus Seriei per  $z$  &  $x$ ; hic terminus revocabitur ad formam  $\overline{a - n z + \frac{n}{m} z \times z + m}$ ; cujus Integrale datur per *Prop. I.*; nempe quoniam  $dx = n$ , &  $dz = m$ , est  $dx = dz \times \frac{n}{m}$ ; unde regrediendo ad integralia fit  $x = \frac{n}{m} z + a$  (adjecto invariabili  $a$ , ut habeatur ratio relationis inter  $z$  &  $x$  in Seriei termino primo,) quod sic scribi potest  $\overline{a - n + \frac{n}{m} \times z + m}$ , ut deinde in  $z$  ductum induat formam requisitam. Et ad eundem modum procedere licet in aliis casibus ejusmodi. Sed ubi formulæ oblatae divisoribus afficiuntur, eadem ac in Calculo integrali, ut vocant, difficultates occurrunt, eadem industria superanda. Nec tamen semper superari possunt. Nam præterquam quod vix certò sciri possit quæ debeat ratio intercedere inter Numeratorem fractionis & Denominatorem, ut formula oblata ad Integrale revocari possit; sæpe etiam difficillimum est explorare an adsit jam talis ratio in formulâ istâ, aut si desit, an introduci possit. Quicquid ego in hac materiâ potissimum inveni, continetur in tribus sequentibus propositionibus.

*Prop. III. Prob.*

Crescentibus,  $z$ ,  $n$ ,  $y$ ,  $x$ , &c. per differentias datas  $n$ ,  $m$ ,  $l$ ,  $o$ , &c. invenire valorem numeratoris integri

regri  $N$ , ut existente Denominatore  $z \cdot \overline{z+n} \cdot \overline{\mathcal{C}c} \cdot \overline{z+pn}$   
 $\times \overline{u \cdot \overline{u+m} \cdot \mathcal{C}c} \cdot \overline{u+qm \times y} \cdot \overline{y+l} \cdot \mathcal{C}c \cdot \overline{y+rl \times x} \cdot \overline{x+e}$   
 $\mathcal{C}c \cdot \overline{x+s} \cdot \mathcal{C}c$ . Fractio ad Integrale revocari possit.

*Solutio.* Fiat  $N = z + pn \times u + qm \times y + rl \times x + s \cdot \mathcal{C}c$ .  
 $\times \mathcal{C}c$ . —  $zu \times y \mathcal{C}c$ . atque Integrale erit fractio, cujus  
 Denominator  $z \cdot \overline{z+n} \cdot \mathcal{C}c \cdot \overline{z+p-1 \times u} \cdot \overline{u+m} \cdot$   
 $\mathcal{C}c \cdot \overline{u+q-1 \times m} \times \overline{y+l} \cdot \mathcal{C}c \cdot \overline{y-x-1 \times l} \times \overline{x+o} \cdot$   
 $\mathcal{C}c \cdot \overline{x+s-1} \cdot \mathcal{C}c$ . existente 1 Numeratore.

Differentia enim hujus fractionis est fractio cujus numerator est ipsius  $N$  valor exhibitus, & denominator idem est ac denominator propositus, ut fieri debuit.

*Ex. 1.* Sic denominator propositus  $z \times \overline{z+2} \times u \times$   
 $\overline{u+3}$ . In hoc casu sunt  $n=2$ ,  $m=3$ ,  $p=1$ ,  $q=1$ ;  
 adeoque est  $N = z + 2 \times u + 3 - zu = 3z + 2u + 6$ ,  
 & per  $\frac{3z + 2u + 6}{z \cdot \overline{z+2} \times u \cdot \overline{u+3}}$  representatur terminus Seriei

summabilis, cujus nempe in infinitum continuatæ summa exhibetur per  $\frac{1}{zu}$ . Sint verbi gratiâ, ipsorum  $z$  &  $u$  primus valor communis 1, atque Series summabilis erit

$\frac{11}{1 \cdot 3 \times 1 \cdot 4} + \frac{23}{3 \cdot 5 \times 4 \cdot 7} + \frac{35}{5 \cdot 7 \times 7 \cdot 10} + \mathcal{C}c$ , quippe  
 cujus totius summa est 1. Per  $p$  designetur ordo termini

cujusvis in hac Serie, erit  $p = \frac{z-1+2}{2} = \frac{u-1+3}{4}$ ,

adeoque  $z = 2p - 1$ , &  $u = 3p - 2$ ; quibus valoribus pro  $z$  &  $u$  scriptis, designabitur terminus per formulam

$\frac{12p-1}{2p-1 \times 2p+1 \times 3p-2 \times 3p+1}$ . Summa

autem terminorum omnium ante terminum illum, hoc est terminorum initialium numero  $\frac{z-1}{2} = p-1$ , est



$1 - \frac{1}{zu} = \frac{zu - 1}{zu}$ , hoc est  $\frac{6pp - 7p + 1}{2p - 1 \times 3p - 2}$ . Qua-

re pro  $p$  scripto  $p + 1$ , erit  $\frac{p \times 6p + 5}{2p + 1 \times 3p + 1}$  aggrega-

tum tot terminorum initialium quot sunt unitates in  $p$ .

*Ex. 2.* Iisdem manentibus  $z, u, n, m$ , sit denomina-  
tor  $z \cdot z + 2 \cdot z + 4 \times u \cdot u + 3$ . Tum per formulam  
numerator erit  $z + 1 \times u + 3 - zu = 3z + 4u + 12$ ,

& summa Seriei exhibebitur per formulam  $\frac{1}{z \cdot z + 2 \times u}$ .

Sit ipsorum  $z$  &  $u$  primus valor communis 1, & hinc eli-

cietur Series  $\frac{19}{1 \cdot 3 \cdot 5 \times 1 \cdot 4} + \frac{37}{3 \cdot 5 \cdot 7 \times 4 \cdot 7} + \frac{55}{5 \cdot 7 \cdot 9 \times 7 \cdot 10}$   
 $+ \&c. = \frac{1}{2}$ .

*Scholium.* In Seriebus jam expositis eadem ubique est  
differentia inter factores continuos ejusdem cujusvis ter-  
mini, ac inter factores homologos terminorum conti-  
nuorum. In sequentibus exempla quædam sunt Serie-  
rum, quarum summæ in terminis numero finitis exhi-  
beri possunt, quamvis ea regula non observetur.

#### Prop. IV. Prob.

Crescente  $z$  per differentias datas  $q, n$ , invenire nu-  
meratorem integrum  $N$ , ut ad Integrale revocari possit  
fractio, cujus Denominator sit ex certo numero  $p$  ter-  
minorum  $z, z + n, z + 2n, \&c.$  Arithmeticè propor-  
tionalium in invicem ductorum. Debet autem esse  $q$   
numerus integer minor quam factorum numerus  $p$ .

*Solutio.* Erit  $N = z + p - 1 \times n \times z + p - 2 \times n \times \&c.$   
 $\times z + p - qn = z \times z + n \times \&c. \times z + q - 1n$ , In-  
tegrale.

regrale existente  $\frac{1}{x \times x + n \times \text{Ec.} \times x + p - q - 1 n}$  De-  
monstratur ad modum propositionis præcedentis.

Sumptis ad libitum  $n$ ,  $p$ ,  $q$ , & primo valore  $x$ , hinc  
oriuntur infinitæ Series summabiles, cujusmodi sunt Se-  
ries tres sequentes.

$$A = \frac{5}{1.2.3.4} + \frac{9}{3.4.5.6} + \frac{13}{5.6.7.8} + \frac{17}{7.8.9.10} \text{ Ec.}$$

$$B = \frac{1}{1.2.3.4.5} + \frac{4}{4.5.6.7.8} + \frac{9}{7.8.9.10.11} \\ + \frac{16}{10.11.12.13.14} + \text{Ec.}$$

$$C = \frac{1}{1.2.3.4.5} + \frac{14}{5.6.7.8.9} + \frac{55}{9.10.11.12.13} \\ + \frac{140}{13.14.15.16.17} + \text{Ec.}$$

Has Series jampridem communicavi cum primariis  
quibusdam Geometris, à quibus minimè contemni vi-  
dentur. Sic ad me scribit peritissimus Geometra D *Nico-*  
*laus Bernoulli* in epistolâ datâ 25 *Julii* 1716. “ Vous  
“ me ferez un extreme plaisir. *Monsieur*, de me com-  
“ muniquer la Solution de vostre probleme, Etant donnée  
“ une suite des Fractions dont les Numerateurs soient des  
“ nombres figurés quelconque, & dont les Denominateurs  
“ soient formés du produit d'un nombre egal de Facteurs  
“ qui soient en Progression Arithmetique, trouver la som-  
“ me; & principalement comment vous avez trouvé

“ ces deux formules  $\frac{p}{24 \times 4p + 1}$ ,  $\frac{p \cdot p + 1}{12 \times 3p + 1 \times 3p + 2}$ .

Hæ formulæ spectant ad Series C & B, designante  $p$   
numerus terminorum, quorum summa requiritur. Sic  
etiam ad me scribit D. *Taylor* in epistola datâ 22 *Aug.*  
1716. “ Ut & quâ ratione incidisti in summationem  
“ Serierum à te exhibitaram, præsertim loquor de  
Series

“ Serie  $\frac{1}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} + \frac{4}{4 \cdot 5 \cdot 6 \cdot 7 \cdot 8} + \frac{9}{7 \cdot 8 \cdot 9 \cdot 10 \cdot 11} + \text{\textit{&c.}}$

“ quæ videtur esse altioris indaginis.

Sed ut ad exempla jam redeamus. In Serie *A* sunt  $p=4$ ,  $q=2$ ,  $n=1$ , primo valore  $z$  existente 1. Est itaque  $z + 3 \times z + 2 = z \times z + 1 = 2 \times 2z + 3$  formula, unde (rejectione dato numero 2) derivantur numeratores 5, 9, 13, 17, &c. Formula etiam summæ est  $\frac{1}{z \times z + 1}$ . Quare habitâ ratione numeri 2, quem ex numeratoribus rejecimus, summa totius Seriei, à termino in quo est  $z$  in infinitum continuatæ, exhibetur per formulam  $\frac{1}{2 \times z \times z + 1}$ ; adeoque summa Seriei integræ est

$$\frac{1}{2 \times 1 \times 2} = \frac{1}{4}$$

In Serie *B* sunt  $n=1$ ,  $p=5$ ,  $q=3$ , primo valore  $z$  existente 1. Est itaque  $N = z + 4 \times z + 3 \times z + 2 = z \times z + 1 \times z + 2 = 6 \times z + 2^2$ . Ipsius autem  $z + 2$  valores continui sunt 3, 6, 9, &c. qui quoniam omnes sunt divisibiles per 3, ponendo  $z + 2 = 3x$ , fit  $N = 6 \times 3x^2 = 6 \times 9x^2 = 54x^2$ , ipsius  $x$  valoribus continuis existentibus 1, 2, 3, &c. Rejectione itaque numero dato 54, hinc procedunt numeratores 1,  $2^2$ ,  $3^2$ , &c. hoc est 1, 4, 9, &c. Formula etiam Integralis est  $\frac{1}{z \times z + 1}$ ; quare habitâ ratione numeri 54 quem ex numeratoribus rejecimus, summa Seriei à termino in quo est  $z$  in infinitum continuatæ est  $\frac{1}{54 \times z \times z + 1}$ . Unde sum-

ma Seriei integræ est  $\frac{1}{108}$ .

In Serie denique *C* sunt  $n=1$ ,  $p=5$ ,  $q=4$ , & primus valor  $z=1$ . Unde fit  $N = z + 4 \times z + 3 \times z + 2 \times z + 1 = z \times z + 1 \times z + 2 \times z + 3 = 4 \times z + 1$

×

$z + 2 \times z + 3$ . Valores autem  $N$  per hanc formulam prodeunt semper possunt dividi per  $4 \times 2 \times 3 \times 4 = 96$ . Ergò hoc divisore rejecto prodeunt numeratores 1, 14, 55, 140, &c. Et formula Summæ, habitâ ratione numeri 96, est  $\frac{1}{96z}$ . Adeoque Summa Seriei integræ est  $\frac{1}{96}$ .

*Scholium* 1. Per Propositiones has duas novissimas nullo negotio inveniri possunt Series quot libuerit summabiles. Et vicissim oblata Serie hujus speciei, si summari potest, ejus summa plerumque revocatur ad alterutram ex his Propositionibus. In examine tamen solertiâ est opus. Optime autem procedit si termini Seriei oblatae revocentur ad formulam *Prop.* III. Sic e. gr.

propositâ Serie  $\frac{7}{3 \cdot 5 \cdot 7 \cdot 9 \cdot 11} + \frac{11}{7 \cdot 9 \cdot 11 \cdot 13 \cdot 15} +$   
 $\frac{15}{11 \cdot 13 \cdot 15 \cdot 17 \cdot 19} + \&c.$  Denominatores sic scribi possunt  $3 \cdot 7 \cdot 11 \times 5 \cdot 9$ ,  $7 \cdot 11 \cdot 15 \times 9 \cdot 13$ ,  $11 \cdot 15 \cdot 19 \times 13 \cdot 17$ . &c.

Unde juxta *Prop.* III. fit  $n = 4$ ,  $m = 4$ ,  $p = 2$ ,  $q = 1$ , primus valor  $z = 3$ , primus valor  $u = 5$ . Hinc formula Numeratoris invenitur  $4 \times z + 2u + 8$ , Est autem  $z + 2u + 8$  semper divisibile per 3; quare rejectis divisoribus datis 4 & 3, per hanc formulam prodeunt Numeratores 7, 11, 15, &c. iidem ac Numeratores in Serie proposita, quæ proinde summabitur per illam propositionem.

2. Cùm Series illas  $A, B, C$ , communicaveram cum *D. Taylor*, rescripsit se earum summas invenisse primam quidem  $A$  & tertiam  $C$ , eas revocando ad casus simplices Methodi Incrementorum, tertiam  $C$ . e. g. revoca-

vit ad hanc formam  $\frac{1}{24} \times \frac{1}{1 \cdot 5} + \frac{1}{5 \cdot 9} + \frac{1}{9 \cdot 13} + \frac{1}{13 \cdot 17} \&c.$ , ut habeatur summa per præcepta tradita in *Scholio Prop.* 1.

In Serie autem secundâ  $B$ , cùm hoc non æquè successit, sequenti usus est Analyfi, quam, ipsius venia jam impetratâ, ob ejus eximiam elegantiam huc transferre non piget. “ Seriei istius terminus [in Stylo ejus] ex-

“ hibetur per formulam  $\frac{z + 2 \times z}{27z \times z + 1 \times z \times z + 1}$  ; pro

$z + 3$  in denominatore scripto  $z$ , quoniam est  $z = 3$ .

“ Pone  $\frac{B}{27C}$  æquale esse Integrali quæsito, hoc est  $\frac{B}{C}$

“ esse Integrale ipsius  $\frac{z + 2 \times z}{z \cdot z + 1 \times z \cdot z + 1}$ , seposito divi-

“ fore dato 27. Ipsius autem  $\frac{B}{C}$  incrementum est

“  $\frac{BC - B'C'}{CC'}$ . Debet ergo  $\frac{BC - B'C'}{CC'}$  idem esse ac

$\frac{z + 2 \times z}{z \cdot z + 1 \times z \cdot z + 1}$ . Comparando denominatores inveni-

“ tur  $C = z \times z + 1$ . Hinc itaque sumendo incremen-

“ ta fit  $C = 2zz + z^2 + z (= 2zz + 4z$ , quoniam

“ est  $z = 3$ .) His valoribus in locum  $C$  &  $C'$  substitu-

“ tis prodit  $BC - B'C' = \underline{zz + z} B - 2z \times z + 2B$ ,

“ quod debet esse idem ac  $z + 2 \times z$ . Sit  $B = a + v$ ,

“ existente  $a$  ipsius  $B$  parte invariabili, &  $v$  parte va-

“ riabili. Tum sumendo incrementa fit  $B = v$ . Unde

“ ad inveniendâ  $a$  &  $v$  habetur æquatio  $zz + zv$

“  $- 2z \times z + 2 \times a + v = z + 2 \times z$ , quæ sic scribi

“ potest  $2z + zv - 2z \times z + 2v = \underline{z \times z + 2 \times 1 + 2a}$

“ vel etiam  $Cv - C'v = \underline{z \times z + 2 \times 1 + 2a}$ . Pone

“  $z + 2a = 0$  (unde fit  $a = -\frac{1}{2}$ ), & fit  $Cv - C'v = 0$ ;

“ ubi

- “ ubi fieri potest  $v = 0$ , (quoniam æquationis termini  
 “ singuli afficiuntur vel ab  $v$ , vel ab  $v$ ) Hinc ergo fit  $B =$   
 “  $a = \frac{-1}{2}$ , adeoque  $\frac{B}{C} = \frac{-1}{2x \times x + 1}$ . Unde habitâ ra-  
 “ tione divisoris 27, Integrale quæsitum fit  $\frac{-1}{54 \times x \times x + 1}$ .  
 “ Sed & comparando æquationem  $C v - C v = 0$  cum  
 “ formulâ generali  $\frac{B C - B C}{C C} = 0$ , inde etiam conclude-  
 “ re licet esse  $\frac{v}{C} =$  quantitati datæ, (quoniam ipsius  
 “ incrementum est 0.) Unde pro  $n$  sumpto quovis  
 “ numero dato, fit  $v = n C$ , atque  $B = \frac{-1}{2} + n C$ .  
 “ Quo pacto Integrale quæsitum fit  $\frac{B}{C} = \frac{-\frac{1}{2} + n C}{C} = \frac{-1}{2C}$   
 “  $+ n$ , quod ab Integrali prius invento differt quan-  
 “ titate datâ  $n$ . Hoc inde fit, quod, ut in quadraturâ  
 “ Curvarum Area inventa augeri potest vel minui areâ  
 “ datâ, sic in Methodo incrementorum Integrale inven-  
 “ tum augeri potest vel minui quantitate datâ. Per  
 “ Integrale autem primum, ubi deest  $n$ , exhibetur  
 “ summa Seriei in infinitum continuatæ.

*Prop. V.*

Crescente  $z$  per unitates, & existentibus  $a, b, c, \&c.$   
 numeris datis integris, quorum nullæ inter se æquantur;  
 invenire Integrale ipsius  $\frac{1}{x \times x + a \times x + b \times x + c \times \&c.}$

*Solutio.* Ducendo tam numeratorem quam denomi-  
 natorem fractionis in terminos  $z + 1, z + 2, \&c.$   
 $z + a + 1, z + a + 2, \&c. z + b + 1, z + b + 2, \&c.$   
 $z + c + 1, z + c + 2, \&c.$  in denominatore deficientes,  
 revocetur Denominator ad formulam  $z \times z + z$

$\times z + 2 \times \mathcal{C}.$  denominatoris in *Prop. I. Schol. n. 3.*  
 Deinde revocetur Numerator ad formam  $A + Bz + Cz$   
 $\times z + 1 + Dz \times z + 1 \times z + 2 + \mathcal{C}.$  Tum appli-  
 cando terminos ad Denominatorem novum  $z \times z + 1$   
 $\times z + 2 \times \mathcal{C}.$  revocetur fractio ad hanc formam  

$$\frac{A}{z \times z + 1 \times \mathcal{C}.} + \frac{B}{z + 1 \times z + 2 \times \mathcal{C}.} + \frac{C}{z + 2 \times z + 3 \times \mathcal{C}.}$$

$$+ \frac{D}{z + 3 \times z + 4 \times \mathcal{C}.} \mathcal{C}.$$
 Unde denique quærat<sup>r</sup> Integrale per *Schol. Prop. I. n. 3.*

Ratio Solutionis per se satis est manifesta.

*Scholium 1.* Hujus Solutionis tota difficultas latet in revocatione numeratoris ad formam requisitam, quod tamen quomodo sit faciendum uno exemplo patebit. Proponatur itaque factum  $z + 2 \times z + 3 \times z + 7$ , quod ad formam propositam sit revocandum. Terminos itaque evolvo gradatim ut sequitur. Factorem primum  $z + 2$  sic scribo  $2 + z$ , cujus terminum primum 2 duco in  $3 + z$ , unde fit  $6 + 2z$ : Terminum secundum  $z$  duco in  $2 + z + 1 (= z + 3)$  unde fit  $2z + z \times z + 1$ . Dein facta in unam summam colligendo, fit  $z + 2$   

$$\times z + 3 = \frac{6 + 2z}{+ 2z} + z \times \frac{z + 1}{z} = 6 + 4z + z \times$$
 $z + 1.$  Superest ut hoc ducatur in  $z + 7$ . Itaque terminum primum 6 duco in  $7 + z (= z + 7)$  unde fit  $42 + 6z$ ; terminum secundum  $4z$  duco in  $6 + z + 1 (= z + 7)$  unde fit  $24z + 4z \times z + 1$ ; terminum tertium  $z \times z + 1$  duco in  $5 + z + 2 (= z + 7)$  unde fit  $5z \times z + 1 + z \times z + 1 \times z + 2.$  Factis itaque in unum collectis ut prius, fit  $z + 2 \times z + 3 \times z + 4$   
 $= 42 + 30z + 9z \times z + 1 + z \times z + 1 \times z + 2.$  Et ad eundem modum procedere licet in aliis casibus.

2. Sic

2. Sit autem exemplum Propositionis in fractione

$\frac{1}{z \times z + 2 \times z + 5}$ . Restituendo factores  $z + 1$ ,  $z + 3$ ,  
 $z + 4$  in Denominatore deficientes, fractio fit

$\frac{z + 1 \times z + 3 \times z + 4}{z \times z + 1 \times z + 2 \times z + 3 \times z + 4 \times z + 5}$ . Revocandus ita-

que est Numerator  $z + 1 \times z + 3 \times z + 4$  ad formam  
 requisitam. Itaque per methodum jam traditam fit

primo  $z + 1 \times z + 3 = 1 \times 3 + z + z \times 2 + z + 1$

$= 3 + z + 2z + z \times z + 1 = 3 + 3z + z \times z + 1$ .

Deinde  $z + 1 \times z + 3 \times z + 4 = 3 \times 4 + z + 3z$

$\times 3 + z + 1 + z \times z + 1 \times 2 + z + 2 = 12 + 3z + 9z$

$+ 3z \times z + 1 + 2z \times z + 1 + z \times z + 1 \times z + 2$

$= 12 + 12z + 5z \times z + 1 + z \times z + 1 \times z + 2$ .

Applicando hoc factum ad Denominatorem  $z \times z + 1 \times$   
*Ec.*  $\times z + 5$  fractio tandem revocatur ad hanc for-

mam  $\frac{12}{z \times z + 1 \times z + 2 \times z + 3 \times z + 4 \times z + 5}$

$+ \frac{12}{z + 1 \times z + 2 \times z + 3 \times z + 4 \times z + 5}$

$+ \frac{5}{z + 2 \times z + 3 \times z + 4 \times z + 5} + \frac{1}{z + 3 \times z + 4 \times z + 5}$

Cujus denique Integrale est  $\frac{1}{5z \times z + 1 \times z + 2 \times z + 3 \times z + 4}$

$+ \frac{-12}{4 \cdot z + 1 \times z + 2 \times z + 3 \times z + 4} + \frac{-5}{3 \cdot z + 2 \times z + 3 \times z + 4}$

$+ \frac{-1}{2 \cdot z + 3 \times z + 4}$ .

3. Quando duo tantum sunt factores  $z$  &  $z + a$ ,  
 exhibebitur etiam Integrale per formulam  $\frac{1}{2} - \frac{1-a}{2z \times z + 1}$

$- \frac{1-a \times 2-a}{3z \times z + 1 \times z + 2} - \frac{1-a \times 2-a \times 3-a}{4z \times z + 1 \times z + 2 \times z + 3} \text{ Ec.}$

Seriem nempe continuando donec abruptatur per eva-  
 nescentiam



nescientiam terminorum. Si Factores duo sint  $z$  &  $z - a$  exhibebitur Integrale per formulam  $\frac{-1}{z-1} = \frac{-1+a}{2 \cdot z-1 \cdot z-2}$   
 $= \frac{-1+a \times -2 \pm 1}{3 \cdot z-1 \cdot z-2 \cdot z-3} = \text{&c.}$  Potest idem Integrale exprimi utroque modo, prout fractionis oblatae factor vel minor vel major sumatur pro  $z$ .

4. Si primus valor  $z$  sit  $a+1$ , migrabit formula posterior in hanc  $\frac{-1}{a} \times \frac{1}{1} \times \frac{1}{2} \times \frac{1}{3} + \text{&c.}$  usque  $\frac{1}{a}$  inclusivè, quâ, cum signo contrario, exhibetur summa Seriesi  $\frac{1}{1 \times 1 + a} + \frac{1}{2 \times 2 + a} + \frac{1}{3 \times 3 + a} + \text{&c.}$  in infinitum continuatæ. Sit e. gr.  $a=1$ , atque Series erit  $\frac{1}{1 \times 2} + \frac{1}{2 \times 3} + \frac{1}{3 \times 4} + \text{&c.} = \frac{1}{1} \times \frac{1}{1} = 1$ . Si  $a=2$ , erit Series  $\frac{1}{1 \times 3} + \frac{1}{2 \times 4} + \frac{1}{3 \times 5} + \text{&c.} = \frac{1}{2} \times \frac{1}{1} + \frac{1}{2} = \frac{3}{4}$ ; Si  $a=3$ , Series erit  $\frac{1}{1 \times 4} + \frac{1}{2 \times 5} + \frac{1}{3 \times 6} + \frac{1}{4 \times 7} + \text{&c.}$   
 $= \frac{1}{3} \times \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{11}{18}$ .

5. Ex eâdem Serie  $\frac{1}{1 \times 1 + a} + \frac{1}{2 \times 2 + a} + \frac{1}{3 \times 3 + a} + \text{&c.}$  pro diverso valore  $a$  oriuntur Series plures formâ satis elegantes, quarum nonnullas Lectori ob oculos sistere, credo, ingratum non erit.

Si pro  $a$  sumantur successivè numeri pares, 2, 4, 6, 8, &c. Series erunt

$$\text{Si } a=2) \frac{1}{1 \times 1 + 2} + \frac{1}{2 \times 2 + 2} + \frac{1}{3 \times 3 + 2} + \frac{1}{4 \times 4 + 2} + \text{&c.}$$

$$4) \frac{1}{1 \times 1 + 4} + \frac{1}{2 \times 2 + 4} + \frac{1}{3 \times 3 + 4} + \frac{1}{4 \times 4 + 4} + \text{&c.}$$

$$6) \frac{1}{1 \times 1 + 6} + \frac{1}{2 \times 2 + 6} + \frac{1}{3 \times 3 + 6} + \frac{1}{4 \times 4 + 6} + \text{&c.}$$

$$8) \frac{1}{1 \times 1 + 8} + \frac{1}{2 \times 2 + 8} + \frac{1}{3 \times 3 + 8} + \frac{1}{4 \times 4 + 8} + \text{&c.}$$

Ve!

$$\text{Vel } \frac{1}{4-1} + \frac{1}{9-1} + \frac{1}{16-1} + \frac{1}{25-1} + \text{etc.}$$

$$\frac{1}{9-4} + \frac{1}{16-1} + \frac{1}{25-4} + \frac{1}{36-4} + \text{etc.}$$

$$\frac{1}{16-9} + \frac{1}{25-9} + \frac{1}{36-9} + \frac{1}{49-9} + \text{etc.}$$

$$\frac{1}{25-16} + \frac{1}{36-16} + \frac{1}{49-16} + \frac{1}{64-16} + \text{etc.}$$

$$\text{Vel } \frac{1}{4-1} + \frac{1}{9-1} + \frac{1}{16-1} + \frac{1}{25-1} + \text{etc.}$$

$$\frac{1}{4+1} + \frac{1}{9+3} + \frac{1}{16+5} + \frac{1}{25+7} + \text{etc.}$$

$$\frac{1}{4+3} + \frac{1}{9+7} + \frac{1}{16+11} + \frac{1}{25+15} + \text{etc.}$$

$$\frac{1}{4+5} + \frac{1}{9+11} + \frac{1}{16+17} + \frac{1}{25+23} + \text{etc.}$$

Si pro  $a$  fumatur successive numeri impares 1, 3, 5, 7;  
 etc. Series erunt

$$1 = 1) \frac{1}{1 \times 1 + 1} + \frac{1}{2 \times 2 + 1} + \frac{1}{3 \times 3 + 1} + \frac{1}{4 \times 4 + 1} + \text{etc.}$$

$$3) \frac{1}{1 \times 1 + 3} + \frac{1}{2 \times 2 + 3} + \frac{1}{3 \times 3 + 3} + \frac{1}{4 \times 4 + 3} + \text{etc.}$$

$$5) \frac{1}{1 \times 1 + 5} + \frac{1}{2 \times 2 + 5} + \frac{1}{3 \times 3 + 5} + \frac{1}{4 \times 4 + 5} + \text{etc.}$$

$$7) \frac{1}{1 \times 1 + 7} + \frac{1}{2 \times 2 + 7} + \frac{1}{3 \times 3 + 7} + \frac{1}{4 \times 4 + 7} + \text{etc.}$$

$$\text{Vel } \frac{1}{2} \times \frac{1}{1} + \frac{1}{3} + \frac{1}{6} + \frac{1}{10} + \text{etc.}$$

$$\frac{1}{2} \times \frac{1}{3-1} + \frac{1}{6-1} + \frac{1}{10-1} + \frac{1}{15-1} + \text{etc.}$$

$$\frac{1}{2} \times \frac{1}{6-3} + \frac{1}{10-3} + \frac{1}{15-3} + \frac{1}{21-3} + \text{etc.}$$

$$\frac{1}{2} \times \frac{1}{10-6} + \frac{1}{15-6} + \frac{1}{21-6} + \frac{1}{28-6} + \text{etc.}$$

$$\text{Vel } \frac{1}{2} \times \frac{1}{1+0} + \frac{1}{3+0} + \frac{1}{6+0} + \frac{1}{10+0} + \text{etc.}$$

$$\frac{1}{2} \times \frac{1}{1+1} + \frac{1}{3+2} + \frac{1}{6+3} + \frac{1}{10+4} + \text{etc.}$$

$$\frac{1}{2} \times \frac{1}{1+2} + \frac{1}{3+4} + \frac{1}{6+6} + \frac{1}{10+8} + \text{etc.}$$

$$\frac{1}{2} \times \frac{1}{1+3} + \frac{1}{3+6} + \frac{1}{6+9} + \frac{1}{10+12} + \text{etc.}$$

6. Ante aliquot annos D. *Jac. Bernoulli* Geometra insignis invenit summam Seriei cujuslibet, cujus Numeratores constituunt Seriem æqualium, Denominatores verò constituunt, vel Seriem quadratorum dato aliquo quadrato  $Q$  minorum, vel Seriem Triangulorum, dato aliquo Triangulo  $T$  minorum. Hæc invenit ille observando quod hujusmodi Series oriuntur ex ablatione Seriei Harmonicæ proportionalium truncatæ ab eâdem Serie integrâ; nempe ita ut numerus terminorum deficientium in Serie truncata, sit, vel duplus lateris dati quadrati  $Q$ , vel duplus unitate auctus lateris dati Trianguli  $T$ . Idem etiam observavit frustrâ quæri summam Seriei reciprocarum Quadratorum. Hoc idem etiam verum est de reciprocis Cuborum, vel aliarum quarumlibet dignitatum numerorum in progressionem Arithmeticâ. Ratio est, quòd nulla intercedit differentia inter factores denominatorum, quod ad hujusmodi summationes semper requiri constat ex Methodo sumendi differentias in *Scholio Prop. I.* jam explicatâ. Nam si per formulam aliquam exhiberi posset summa quæsitâ, differentia istius formulæ exhiberet terminos Seriei propositæ: sed in tali differentiâ denominator semper afficitur per factores ab invicem diversos, quod quoniam in Seriebus prædictis non obtinet, summæ Serierum hujusmodi in terminis finitis haberi nequeunt. Ad eundem ferè modum, argumento petito à *Prop. III. & IV.* demonstrari potest summam Serierum exhiberi non posse in terminis numero finitis, quarum Numeratores constituunt Seriem æqualium. Denominatores vero constant ex certo numero terminorum in progressionem Arithmeticâ, maximo factore cujusvis termini minore existente quàm factor minimus in termino proxime insequenti, cujusmodi est Series  $\frac{1}{1 \cdot 2} + \frac{1}{3 \cdot 4} + \frac{1}{5 \cdot 6} + \text{c}^c.$

7. Jam liceret regulas nonnullas tradere quas pro casibus quibusdam singularibus concinnavi; sed hæc  
nos

nos longius abducerent. Sufficiat itaque quæ generaliora sunt explicasse, & simul monuisse, ad novæ hujusce Serierum infinitarum doctrinæ provectionem nihil magis facere, quam si excogitentur formulæ generaliores summarum, ex quarum differentiis, per regulas supra traditas computatis, deinde conficiantur Canones quantitarum summabilium; ita ferè ut jam factum est in Calculo Integrali, *h. e.* in Stylo *Newtoniano*, in Methodo Fluxionum.

8. Restituendo factores in Denominatore deficientes potuisset præsens Problema revocari ad *Propositionem* II. Sed & in terminis generalioribus proponi potest, nempe pro Numeratore sumptâ quâvis Formulâ, cujus differentia aliqua datur. Sub eâ tamen conditione ut dimensiones Denominatoris ad minimum binario superent Dimensiones Numeratoris: aliàs enim summa Seriei in terminis numero finitis haberi nequit.

Sit hujus rei exemplum in Serie  $\frac{1}{1.3.5.7} + \frac{4}{2.4.6.8} + \frac{9}{3.5.7.9} + \frac{16}{4.6.8.10} + \text{Ec.}$  ubi Numeratores sunt

numerorum naturalium quadrata. Applicando tum Numeratores tum Denominatores ad numeros naturales,

Series revocatur ad formam simpliciorum  $\frac{1}{3.5.7} + \frac{2}{4.6.8} + \frac{3}{5.7.9} + \frac{4}{6.8.10} + \text{Ec.}$  Per  $p$  designatis numeris naturalibus 1, 2, 3, 4, &c. terminus Seriei designabitur per formulam

$\frac{p}{p + 2 \times p + 4 \times p + 6}$ ; vel per formulam

$\frac{z-2}{z \times z + 2 \times z + 4}$ , nempe pro  $p + 2$  scripto  $z$ . Quoniam

progrediendo de termino in terminum augetur  $z$  per unitates, restituendi sunt factores in denominatore deficientes  $z + 1$ ,  $z + 3$ , & hoc pacto revocatur terminus Seriei ad formulam

$\frac{z-2 \times z + 1 \times z + 3}{z \times z + 1 \times z + 2 \times z + 3 \times z + 4}$

Per methodum in hac Propositione jam explicatam revocatur

M m m m m

vocatur

vocatur numerator ad formam  $-6 - 6z - z \times z + 1$   
 $+ z \times z + 1 \times z + 2$ . Unde habita ratione denomi-  
 natoris Terminus revocatur ad formam  $\frac{-6}{z \times z + 1 \times z + 2}$

$+ \frac{-6}{z + 1 \times z + 2 \times z + 3 \times z + 4}$   $+ \frac{-1}{z + 2 \times z + 3 \times z + 4}$   
 $+ \frac{1}{z + 3 \times z + 4}$ . Adeoque sumendo Integrale fit

$\frac{4z \times z + 1 \times z + 2 \times z + 3}{3 \times z + 1 \times z + 2 \times z + 3}$   $+ \frac{6}{2 \times z + 2 \times z + 3}$   $+ \frac{-1}{z + 3}$ ; quo, sub signo contra-  
 rio, exhibetur summa Seriei in infinitum continuatæ,  
 incipientis à termino  $\frac{z-2}{z \times z + 2 \times z + 4}$ . Summa itaque

Seriei integræ incipientis à termino  $\frac{1}{3 \cdot 5 \cdot 7}$  est  $\frac{31}{240}$ .

Si per Prop. II. procedere esset animus, ex formulâ  
 $z - 2 \times z + 1 \times z + 3$  collectis numeratoribus primis  
 24, 70, 144, 252, sumendo eorum differentias habe-  
 rentur  $46 = b$ ,  $28 = c$ ,  $6 = d$ ,  $e = 0 = \&c.$  existente  
 $M = 24$ ; unde per Lem. 2. prodiret formula  $-6 - 6z$   
 $- z \times z + 1 + z \times z + 1 \times z + 2$ , quâ designatur Ter-  
 minus, eadem ac supra; atque pergendo per Prop. II.  
 haberetur summa.

*Prop. VI. Prob.*

Invenire summam quotlibet terminorum Seriei Fra-  
 ctionum, quarum Numeratores & Denominatores con-  
 stituunt lineas duas qualvis transversas in Triangulo  
 Arithmetico *Paschalii*; nempe cujus generatores sunt  
 unitates.

*Solutio.* Per  $n$  designetur Ordo Seriei Numeratorum  
 in Triangulo Arithmetico, & sit  $p$  differentia inter  
 ordinem Numeratorum & Denominatorum, & per  $q$   
 designetur numerus terminorum quorum summa re-  
 quiritur

quiritur. Tum si Denominatores sint plurium dimensionum quàm sunt Numeratores, Summa exhibebitur per formulam primam sequentem; si dimensiones Numeratorum plures sint quàm dimensiones Denominatorum, Summa exhibebitur per formulam secundam.

*Formula I.*

$$\frac{n+p-1}{p-1} = \frac{n \cdot n-1 \cdot n+2 \cdot \&c. n+p-1}{p-1 \times n-1 \cdot q \cdot n+q+1 \cdot \&c. n+q+p-2}$$

*Formula II.*

$$= \frac{n-p-1}{p+1} + \frac{q+n-1 \cdot q+n-2 \cdot \&c. q+n-p-1}{p+1 \times n-1 \cdot n-2 \cdot \&c. n-p}$$

*Ex. 1.* Inveniendum sit aggregatum sex primorum terminorum Seriei  $\frac{1}{1} + \frac{4}{7} + \frac{10}{28} + \frac{20}{84} + \frac{35}{210} + \frac{56}{462} + \&c.$  ubi Numeratores constituunt lineam quartam, Denominatores constituunt lineam septimam in Triangulo Arithmetico. Sunt itaque  $n=4$ ,  $p=3$ ,  $q=6$ ; & quoniam dimensiones Denominatorum superant dimensiones Numeratorum, dabitur summa per Formulam primam; nempe  $\frac{4+3-1}{3-1} = \frac{4 \cdot 5 \cdot 6}{3-1 \times 4 + 6 \times 4 + 7}$  five  $3 - \frac{6}{11} = 2 \frac{5}{11}$ .

*Ex. 2.* Quæratum summa sex primorum terminorum Seriei  $\frac{1}{1} + \frac{7}{4} + \frac{28}{10} + \frac{84}{20} + \frac{210}{35} + \frac{462}{56} + \&c.$  cujus termini sunt terminorum Seriei prioris reciproci. Sunt itaque  $n=7$ ,  $p=3$ ,  $q=6$ , adeoque per formulam secundam summa fit  $= \frac{3}{4} + \frac{12 \cdot 11 \cdot 10 \cdot 9}{4 \times 6 \cdot 5 \cdot 4} = 24$ .

*Scholium 1.* Formulas in hac propositione exhibitas ante biennium communicavi cum Viris celeberrimis *Moiswreo & Bernoulliis*. Facile autem derivari possunt ex præceptis in *Prop. I.* traditis. Sit exemplum in Serie priori  $\frac{1}{1} + \frac{4}{7} + \frac{10}{28} + \&c.$  Per  $p$  designato loco

Ter-

Termini in Serie hâc, exhibetur Terminus per formulam

$\frac{4 \cdot 5 \cdot 6}{p+3 \cdot p+4 \cdot p+5}$ ; Unde regrediendo ad Integrale,

summa Seriei incipientis à termino illo exhibetur per formulam  $\frac{4 \cdot 5 \cdot 6}{2 \times p+3 \times p+4}$ ; adeoque pro  $p$  sumpto 1, Se-

ries integra fit  $\frac{4 \cdot 5 \cdot 6}{2 \cdot 4 \cdot 5} = 3$ , atque summa primorum

sex terminorum fit  $3 - \frac{4 \cdot 5 \cdot 6}{2 \cdot 10 \cdot 11}$ , omninò ut per formulam jam exhibetur.

2. In formulâ primâ summa Seriei in infinitum continuatâ est  $\frac{n+p-1}{p-1}$ , evanescente jam parte alterâ formulæ. Sed in casu formulæ secundæ summa hæc est

infinitum quid, cujus species, respectu numeri infiniti  $q$ , exhibetur per formulæ partem alteram, quæ in hoc casu fit  $\frac{q^{p+1}}{p+1 \times n-1 \cdot n-2 \cdot \&c. n-p}$ .

3. De hujusmodi Seriebus in epistolâ datâ mense Maio 1716, sic ad me scripsit Vir. Ill. D. Leibnitius, quem magno Scientiarum damno nobis nuper ereptum lugemus. “ Il me semble qu'autrefois j'ay aussi sommé

“ quelques Series ou suites comme  $\frac{1}{1} + \frac{2}{4} + \frac{3}{10} + \frac{4}{20}$

“  $+ \frac{5}{35} + \frac{6}{56} + \&c.$  Le terme de cette suite exprimé

“ Analytiquement est  $\frac{x}{x \cdot x+1 \cdot x+2 \times \frac{1}{1} \cdot \frac{1}{2} \cdot \frac{1}{3}}$

“  $= \frac{1 \cdot 2 \cdot 3}{x+1 \cdot x+2} = \frac{6}{xx+3x+2}$ . On demande donc

“ la somme d'une suite donnéé, dont un terme soit

“  $\frac{ll}{xx+3lx+2ll}$  ou  $x$  signifie les nombres naturelles

“ 1, 2, 3, 4, &c. &  $l$  signifie l'Unité, ou la difference

“ des  $x$ . Supposons que le terme de la suite som-

“ matrice

matrice demandée soit  $\frac{fx}{mx+nl} = \frac{\odot}{\mathfrak{D}}$ . Or Diff.  $\frac{\odot}{\mathfrak{D}} =$

$$-\frac{\odot}{\mathfrak{D}} + \frac{\odot + d\odot}{\mathfrak{D} + d\mathfrak{D}} = \frac{\mathfrak{D} d\odot - \odot d\mathfrak{D}}{\mathfrak{D}\mathfrak{D} + \mathfrak{D}d\mathfrak{D}} : \text{sed } d\odot = fdx,$$

&  $d\mathfrak{D} = m dx = ml$ ; donc la Différence de  $\frac{\odot}{\mathfrak{D}}$  est =

$$\frac{nfl}{mxx + 2mnlx + nnl}. \text{ Maintenant il faut faire}$$

$$\frac{nfl}{mxx + 2mnlx + nnl} = \frac{mfl}{mxx + 3mnlx + 2mmll}$$

c'est à dire, il faut identifier ces deux formules, ou la

donnée est Multipliée par  $\frac{nf}{mm}$ : donc égalant les

termes respectifs, puisque les  $xx$  conviennent, on

aura par les  $x$ ,  $2n+m=3m$ , c'est à dire il y aura

$m=n$ , & par les absolus on aura  $nn+mn=2mm$ ,

ce qui donne encore  $m=n$ ; donc l'identification

reussit, & nous pouvons faire  $n=m=l=1$ , &

$f=1$  (car  $f$  demeure arbitraire) & le terme de la

suite sommatrice sera  $\frac{x}{x+1}$ , car diff.  $\frac{x}{x+1}$  donne

$$-\frac{x}{x+1} + \frac{x+1}{x+2} = \frac{1}{xx+3x+2}, \text{ \& par conséquent}$$

$$\frac{6x}{x+1} \text{ donne la somme des } \frac{x}{x \cdot x + 1 \cdot x + 2 \times \frac{1}{2} \cdot \frac{1}{2}}$$

3, 4,  $\frac{9}{2}$ ,  $\frac{24}{5}$ , 5,  $\frac{36}{7}$ , &c. *Series summatrix, cujus ser-*

$$\text{minus } \frac{6x}{x+1}.$$

$$\frac{1}{1} + \frac{2}{4} + \frac{3}{9} + \frac{4}{16} + \frac{5}{25} + \&c. \text{ Series summanda, cu-}$$

$$\text{jus terminus } \frac{x}{x \cdot x + 1 \cdot x + 2 \times \frac{1}{2} \cdot \frac{1}{2}}. \text{ Et pour}$$

s'en servir aux sommations, les 5 termes, par Ex. de



“ la suite donnée seront  $\frac{36}{7} - 3 = \frac{15}{7}$ . Et générale-  
 “ ment la somme des termes jusqu'à quelque terme  
 “  $\frac{x}{x \cdot x + 1 \cdot x + 2 \times \frac{1}{1} \cdot \frac{1}{2} \cdot \frac{1}{3}}$  exclusivement, sera  $\frac{6x}{x+1}$   
 “  $- 3$  : Et pour la somme de la suite entière à l'infi-  
 “ nie,  $x$  devient infini, &  $\frac{6x}{x+1} = 6$  : donc la somme  
 “ de toute la suite est  $6 - 3 = 3$ , comme vous  
 “ l'avez trouvé.  
 “ Cette méthode est le calcul des différences ap-  
 “ pliqué aux Nombres ; & il faut vous avouer qu'a-  
 “ vant que de l'appliquer aux Figures, & même avant  
 “ que d'avoir été Geometre, Je le pratiquai en quel-  
 “ que façon dans les nombres ; ayant trouvé encore  
 “ jeune garçon que les suites dont les Numerateurs  
 “ fussent des Unites, & dont les Denominateurs fussent  
 “ les Nombres figurés, comme Triangulaires Pyrami-  
 “ daux &c. étoient les différences 1<sup>eres</sup>, 2<sup>es</sup>, 3<sup>emes</sup>, &c.  
 “ multipliées par les constantes de la suite  $\frac{1}{1} + \frac{1}{2} + \frac{1}{3}$   
 “  $+ \frac{1}{4} + \&c.$  & par conséquent sommables. Mais  
 “ quand je devins un peu Geometre & Analyste, Je  
 “ vis qu'il y avoit moyen de venir à bout de telles  
 “ formations par une Méthode générale, autant qu'il  
 “ étoit possible ; & que le calcul des différences étoit  
 “ encore plus commode dans la Geometrie que dans  
 “ les Nombres, puis qu'il y a plus d'évanouissements,  
 “ & que les différences repondent aux Tangentes, les  
 “ sommes aux Quadratures. Cette méthode générale  
 “ de chercher la suite sommatrice de la suite donnée,  
 “ quand elle est possible, réussit toujours, quand le terme  
 “ de la suite donnée exprimé Arbitrairement n'a  
 “ point la quantité variable enveloppée dans une racine,  
 “ ny entrant dans l'exposant ; & alors, on peut tou-  
 “ jours

“ jours déterminer la suite sommatrice, ou prouver  
 “ qu’il est impossible d’en trouver. Et la chose reussit  
 “ même bien souvent, lors même que la variable en-  
 “ tre dans l’Exposant. Mais comme il y a quelque-  
 “ fois des Quadratures particulieres de quelques por-  
 “ tions d’une Figure, dont on ne sçauroit donner la  
 “ Quadrature generale ou la Figure quadratrice ; de  
 “ même on peut trouver quelquefois la somme de  
 “ toute la suite, ou d’un certaine partie, quoy qu’on  
 “ ne puisse pas trouver la somme de chaque partie ; &  
 “ alors il faut avoir recours a des Methodes particulieres,  
 “ dont on n’est pas toujours le maître, nostre Analyse  
 “ n’étant pas encore portée a sa perfection.

*Prop. VII. Prob.*

Invenire summam Seriei cujus Numeratores consti-  
tuunt lineam quamlibet erectam in Triangulo Arith-  
metico *Paschalii*, Denominatores vero constituunt li-  
neam quamlibet transversam.

*Solutio.* Designetur ordo lineæ erectæ per  $p$ , ordo  
lineæ transversæ per  $q$ , & sit  $m$  aggregatum tot termino-  
rum primorum in lineâ erectâ ordinis  $p + q - 1$  quot  
sunt unitates in  $q - 1$ , atque summa quæsitæ erit

$$2^{p+q-2} - m \times \frac{1 \cdot 2 \cdot 3 \cdot \text{Ec. } q-1}{p \cdot p+1 \cdot \text{Ec. } p+q-2}.$$

*Ex. 1.* Proponatur Series  $\frac{1}{1} + \frac{5}{4} + \frac{10}{10} + \frac{10}{20} + \frac{5}{35} + \frac{1}{56}$

Ubi Numeratores constituunt lineam sextam erectam,  
Denominatores occupant lineam quartam transversam.  
In hoc itaque casu sunt  $p = 6$ ,  $q = 4$ ,  $p + q - 1 = 9$ ,  
 $q - 1 = 3$ , adeoque  $m = 1 + 8 + 28 = 37$  i. e. tribus  
terminis primis lineæ nonæ erectæ. Unde fit summa

$$\text{quæsitæ } 2^3 - 37 \times \frac{1 \cdot 2 \cdot 3}{6 \cdot 7 \cdot 8} = \frac{219}{56}.$$

*Ex. 2.* Constituant Numeratores lineam centesimam  
erectam, & sint Denominatores Numeri Trigonaes, qui  
occupant lineam tertiam transversam. Tum erunt

$p=100, q=3, m=102$  atque adeo summa quaesita fit

$$\frac{2^{101}}{2} = 102 \times \frac{1 \cdot 2}{100 \cdot 101}.$$

*Cor.* Si  $q=2$ , formula fit  $\frac{2^p-1}{p}$ , quâ exhibetur aggregatum primi termini, unâ cum semissâ secundi, triente tertii, quadrante quarti, & sic porro, linearum cujuscunque erectæ ordinis  $p$  Trianguli Arithmetici *Paschalis*.

Sic *v. gr.* est  $\frac{1}{1} + \frac{5}{2} + \frac{10}{3} + \frac{10}{4} + \frac{5}{5} + \frac{1}{6} = \frac{2^6-1}{6} = 10 \frac{1}{2}$ .

### *Prop. VIII. Prob.*

Invenire summam ejusdem Series, quando terminorum signa sunt alternatim  $+$  &  $-$ .

*Solutio.* Summa quaesita exhibetur per formulam simplicissimam  $\frac{q-1}{p+q-2}$ .

*Ex.* Invenienda sit summa Series  $\frac{1}{1} - \frac{6}{9} + \frac{28}{45} - \frac{20}{165} + \frac{18}{495} - \frac{6}{1287} + \frac{1}{3003}$ , ubi Numeratores constituunt lineam septimam erectam, Denominatores constituunt nonam transversam. In formulâ itaque pro  $p$  &  $q$  scriptis 7 & 9, fit summa  $\frac{8}{14}$ .

Manente eadem Serie Numeratorum (nempe lineâ septimâ erectâ), si pro Serie Denominatorum sumantur successive lineæ transversæ 2<sup>da</sup>, 3<sup>ia</sup>, 4<sup>ta</sup>, &c. Summæ erunt  $\frac{1}{7}, \frac{2}{8}, \frac{3}{9}, \frac{4}{10}, \frac{5}{11}$ , &c. quæ sic possunt scribi,

$\frac{1}{7}, \frac{7}{28}, \frac{28}{84}, \frac{84}{210}, \frac{210}{462}$ , &c. ubi tam Numeratores, quam Denominatores excerpuntur ex lineâ transversâ ordinis septimi. Idem eveniret si loco septimæ, Numeratores constituissent aliam quamlibet lineam erectam ordinis  $p$ ; Summæ quippe orientur ex applicatione terminorum

linearum

lineæ transversæ ejusdem ordinis  $p$  ad terminos proximè sequentes in eadem lineâ.

Propositiones hæc duæ novissimæ potius elegantes sunt quàm utiles; quare Formularum nostrarum demonstrationem Lectoris solertia investigandam relinquimus, ad Propositionem ultimam jam properantes, quæ tertiam continet Serierum speciem, ob usum multiplicem satis insignem.

*Lemma 5.*

Sit Series quævis  $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}, \&c.$  cujus terminorum Denominatores constituunt progressionem quamlibet Geometricam  $b, b^2, b^3, b^4, \&c.$  Sint etiam Numeratorum primus  $A (= M)$ , prima differentiarum primarum  $B$ , prima secundarum  $C$ , prima tertiarum  $D$ , quartarum  $E$ , & sic porro; & sint  $\frac{\alpha}{b}, \frac{\beta}{b^2}, \frac{\gamma}{b^3}, \frac{\delta}{b^4}, \&c.$  respectivè, aggregata, Unius, Duorum, Trium, Quatuor, vel plurium terminorum Seriei  $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \&c.$  atque sint Numeratorum primus  $a (= \alpha)$  prima differentiarum primarum  $b$ , prima secundarum  $c$ , prima tertiarum  $d$ , & sic porro: & sit  $b - 1 = q$ . Tum ipsorum  $a, b, c, d, \&c.$  valores erunt.

$$\begin{aligned} a &= A = \alpha = M \\ b &= bA + B \\ c &= qbA + bB + C \\ d &= q^2bA + qbB + bC + D \\ &\& \text{ sic porro.} \end{aligned}$$

*Demonstratio.*

Satis constat esse  $a = \alpha = A = M$ .

Termini  $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}, \&c.$  Numeratoribus  $M, N, O, P, \&c.$

O o o o o

$\&c.$  expressis per  $A, B, C, D$ ,  $\&c.$  transformantur in terminos  $\frac{A}{b}, \frac{A + B}{b^2}, \frac{A + 2B + C}{b^3}, \frac{A + 3B + 3C + D}{b^4}$

$\&c.$  Unde colligendo summas terminorum, inveniuntur Numeratores  $\alpha, \beta, \gamma, \delta$ ,  $\&c.$  nempe

$$\begin{aligned}\alpha &= A \\ \beta &= \frac{b + 1}{b^2} A + \frac{B}{b^2} \\ \gamma &= \frac{b^2 + b + 1}{b^3} A + \frac{b + 2}{b^3} B + \frac{C}{b^3} \\ \delta &= \frac{b^3 + b^2 + b + 1}{b^4} A + \frac{b^2 + 2b + 3}{b^4} B + \frac{b + 3}{b^4} C + \frac{D}{b^4} \\ &\&c.\end{aligned}$$

Unde sumendo differentias fiunt

$$\begin{aligned}b &= *b A + B \\ c &= q b A + b B + C \\ d &= q q b A + q b B + b C + D\end{aligned}$$

& sic porro, ut in Propositione exhibentur.

*Cor. 1.* Si Numeratorum  $M, N, O, P$ ,  $\&c.$  differentia vel prima, vel secunda, vel alia quædam detur, terminis omnibus post primos aliquot in Serie  $A, B, C, D$ ,  $\&c.$  evanescentibus, Differentiæ  $b, c, d$ ,  $\&c.$  tandem incurrent in Progressionem Geometricam in ratione 1 ad  $q$ . Exempli gratiâ, si detur Numeratorum  $M, N, O, P$   $\&c.$  differentia prima  $B$ , erunt  $c, d$ ,  $\&c.$  in ratione continuâ Geometricâ 1 ad  $q$ ; ut constat per ipsorum valores  $q b A + b B$ ,  $q q b A + q b B$ ,  $\&c.$  existentibus  $C = 0 = D = \&c.$

*Cor. 2.* Ordo autem primarum differentiarum  $B, C, D$ ,  $\&c.$  quæ hoc modo evanescent, idem est ac ordo differentiæ vel  $b$ , vel  $c$ ,  $\&c.$  unde incipit Progressio illa Geometrica. Sic si  $B = 0 = C = \&c.$  erunt  $b, c, d$ ,  $\&c.$  in Progressione Geometricâ; si  $C = 0 = D = \&c.$  erunt  $c, d$ ,  $\&c.$  in Progressione Geometricâ. Et sic porro.

#### Lemma 6.

Iisdem positis sit  $r$  terminus unde incipit Progressio Geometrica in Serie differentiarum  $b, c, d$ ,  $\&c.$  & per

$p+1$  designetur ordo Termini in Serie  $\frac{a}{b}, \frac{\beta}{b^2}, \frac{\gamma}{b^3}, \frac{\delta}{b^4},$

*&c.* Tum Terminus ille designabitur per fractionem  
cujus Denominatore existente  $b^{p+1}$  Numerator est

$$\frac{a + bp + cp \times \frac{p-1}{2} + dp \times \frac{p-1}{2} \times \frac{p-2}{3} + \text{&c.} + \frac{p}{p!}}$$

$$\times b^p - 1 - qp - q^2 p \times \frac{p-1}{2} - q^3 p \times \frac{p-1}{2} \times \frac{p-2}{3} - \text{&c.}$$

nempe per  $n$  designato ordine differentiae evanescentis  
in Serie  $B, C, D, \text{&c.}$  ut & Numero terminorum  
 $a + bp, \text{&c.}$  item terminorum  $-1 - qp, \text{&c.}$

*Demonstratio.* Per *Lemma 1.* Termini istius Numerator exhibetur per formulam

$$a + bp + cp \times \frac{p-1}{2} + dp \times \frac{p-1}{2} \times \frac{p-2}{3} + \text{&c.} (p+1$$

subeunte vices  $x$  in Lemmate isto)

Ergo si sit, *ex. gr.*  $n=2$ , per *Lemm. 5. Cor. 2.* erunt  
 $c, d, \text{&c.}$  in ratione continuâ 1 ad  $q$ . Numerator itaque  
in hoc casu est

$$a + bp + cp \times \frac{p-1}{2} + cqp \times \frac{p-1}{2} \times \frac{p-2}{3} + cq^2 p$$

$$\times \frac{p-1}{2} \times \frac{p-2}{3} \times \frac{p-3}{4} + \text{&c.}$$

Sed si termini  $cp \times \frac{p-1}{2}$   
 $+ cqp \times \frac{p-1}{2} \times \frac{p-2}{3} + \text{&c.}$  ducantur in  $\frac{q}{c}$ , & produ-  
ctui addantur termini  $1 + qp$ , prodibit Series quâ ex-  
primitur binomii  $1 + q$  dignitas  $1 + q^p = b^p$ . Ergo  
productum illud æquale est  $b^p - 1 - qp$ ; adeoque ter-  
mini  $cp \times \frac{p-1}{2} + cqp \times \frac{p-1}{2} \times \frac{p-2}{3} + \text{&c.} = \frac{c}{q}$   
 $\times b^p - 1 - qp$ . Quo pacto Numerator fit  $a + bp$   
 $+ \frac{c}{q} \times b^p - 1 - qp$ , existentibus duobus terminis  $a + bp$ ,  
ut & duobus  $-1 - qp$ , juxta sensum Propositionis,  
quoniam  $n=2$ . Atque eadem est demonstratio in aliis  
casibus. De Denominatore verò per se satis constat.

*Prop.*

## Prop. IX. Prob.

Invenire summam quotlibet terminorum Series cu-  
jusvis  $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}, \&c.$  cujus terminorum Denomina-  
tores constituunt progressionem quamlibet Geometri-  
cam  $b, b^2, b^3, b^4, \&c.$  Numeratores autem sunt quan-  
titates differentiâ aliquâ constanti gaudentes.

*Solutio* Sunto Numeratorum  $M, N, O, P, \&c.$  pri-  
mus  $A$ , prima differentiarum primarum  $B$ , prima se-  
cundarum  $C$ , prima tertiarum  $D$ , & sic porro; & sit  
ipsum  $A, B, C, D, \&c.$  numerus  $n$ , atque  $b - 1 = q$ ,  
Tum fiat  $a = A (= M)$   $b = b A + B$ ,  $c = q b A + b B$   
 $+ C$ ,  $d = q^2 b A + q b B + b C + D$ ,  $\&c.$  ut sint  
tot termini  $a, b, c, d, \&c.$  quot sunt unitates in  $n + 1$ .  
Terminorum istorum ultimus dicatur  $r$ , atque per  $p + 1$   
designetur numerus terminorum  $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}, \&c.$  quo-  
rum summa requiritur; Dico summam illam exhiberi  
per fractionem, cujus Denominatore existente  $b^{p+1}$ ,  
Numerator est

$$\frac{a + b p + c p \times \frac{p-1}{2} + d p \times \frac{p-1}{2} \times \frac{p-2}{3} + \&c. + \frac{r}{q^n}}{\times b^p - 1 - q p - q^2 p \times \frac{p-1}{2} - q^3 p \times \frac{p-1}{2} \times \frac{p-2}{3} - \&c. - q^{n-1} p \times \frac{p-1}{2} \times \&c.}$$

*Demonstratio.* Nam (per Lem. 6.) per hanc formulam  
repræsentatur terminus ordine  $p + 1$  Seriesi  $\frac{\alpha}{b}, \frac{\beta}{b^2}, \frac{\gamma}{b^3},$   
 $\frac{\delta}{b^4}, \&c.$  qui terminus (per constructionem Lemmatis 5.)  
æqualis est aggregato terminorum numero  $p + 1$  Seriesi  
propositæ  $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}, \&c.$   $\mathcal{Q} E. D.$

*Ex. 1.* Inveniendā sit summa novem terminorum Seriesi  $\frac{1}{2}, \frac{2}{4}, \frac{3}{8}, \frac{4}{16}, \&c.$  Sunt in hoc casu  $b=2, q$   
 $(=b-1)=1, p+1=9, p=8, A=1, B=1,$   
 $C=0, D=\&c.$  adeoque  $n=2$ , (quoniam sunt duo  
 $A, B$ .) Hinc fit  $a(=A)=1, b(=bA+B=2 \times 1+1)$   
 $=3, c(=qbA+bB+C=2 \times 1+2 \times 1+0)$   
 $=4=r$ , Adeoque per formulam fit summa quæsitā  

$$\frac{1+3 \times 8+\frac{4}{1^2} \times 2^3-1-1 \times 8}{2^9}=\frac{1013}{512}.$$

*Ex. 2.* Quæratūr summa sex terminorum Seriesi  $1 \times 3$   
 $+ 3 \times 3^2 + 6 \times 3^3 + 10 \times 3^4 + 15 \times 3^5 + 21 \times 3^6 + \&c.$   
 In hoc casu sunt  $b=\frac{1}{3}, q=\frac{-2}{3}, p+1=6, p=5,$   
 $A=1, B=2, C=1, D=0=E=\&c.$  adeoque  
 $n=3$ , atque  $a=1, b=\frac{1}{3}+2=\frac{7}{3}, c=\frac{-2}{9}+\frac{2}{3}+$   
 $1=\frac{13}{9}, d=\frac{4}{27}-\frac{4}{9}+\frac{1}{3}=\frac{1}{27}=r$ . Unde summa quæ-  
 sita fit  $=19956$ . five

$$\frac{1+\frac{7}{3} \times 5+\frac{13}{9} \times 5 \times \frac{4}{2}+\frac{-1}{8} \times \frac{1}{3^5}-1+\frac{2}{3} \times 5-\frac{4}{9} \times 5 \times \frac{4}{2}}{\frac{1}{3} \left| \begin{array}{c} 10 \\ 3 \end{array} \right|}$$

*Cor. 1.* Ejusdem Seriesi, à termino primo  $\frac{M}{b}$  in infinitum continuatæ, summa exhibetur per formulam simplicissimam  $\frac{A}{b-1} + \frac{B}{b-1}^2 + \frac{C}{b-1}^3 + \frac{D}{b-1}^4 + \&c.$

*Cor. 2.* Si  $b=2$ , Seriesi totius in infinitum continuatæ summa habetur solâ additione terminorum  $A, B, C, D, \&c.$  Et hæc summa eadem est ac summa lineæ erectæ respondentis termino primo  $A$ , in Triangulo Arithmetico, cujus lineam transversam occupant Num-



ratores  $M, N, O, P, \&c.$  Quod facile constat ex contemplatione Trianguli. Si itaque fuerint  $M, N, O, \&c.$

Numeri figurati cujusvis ordinis  $n$ , summa Seriei  $\frac{M}{2}$   
 $+\frac{N}{4}+\frac{O}{8}+\frac{P}{16}+\&c.$  æqualis erit Numeri binarij

dignitati  $2|^{n-1}$ . Sic Series  $\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\&c.=$

$2^{1-1}=1$ , ut vulgò notum; Series  $\frac{1}{2}+\frac{2}{4}+\frac{3}{8}+\frac{4}{16}$

$+\&c.=2^{2-1}=2$ ; Series  $\frac{1}{2}+\frac{3}{4}+\frac{6}{8}+\frac{10}{16}+\&c.=$

$2^{3-1}=2^2=4$ , & sic porrò.

*Scholium.* Celeb. D. Jac. Bernoulli, in Tractatu suo de Seriebus infinitis, solvit illud Problema. "Invenire  
 " summam Seriei infinitæ Fractionum quarum Denomi-  
 " natores crescunt in Progressione quacunque Geome-  
 " tricâ, Numeratores verò progrediuntur vel juxta Nu-  
 " meros naturales, 1, 2, 3, 4, &c. vel Trigonaes 1,  
 " 3, 6, 10, &c. vel Pyramidales 1, 4, 10, 20, &c.  
 " aut juxta Quadratos 1, 4, 9, 16, &c. aut Cubos 1,  
 " 8, 27, 64, &c. eorumve multiplices." Ipsius solu-  
 tionem consulat Lector. Aliam verò, & quidem mul-  
 to generaliorem invenit D. Nic. Bernoulli illius Nepos,  
 eamque (postquam ei hæc miseram, sed sine demon-  
 stratione) mecum communicare dignatus est, in epistolâ  
 datâ 18<sup>o</sup> Septembris 1715, miris quidem inventis refer-  
 tissimâ, quâlibet me crebro dignatur vir Doctissimus.  
 De hoc vero Problemate sic scribit. "Pour la somme  
 " d'un nombre déterminé  $n$  de termes de la suite de  
 " vostre Theoreme 7. [Corollarium primum est hujus

Propositionis] j'ay trouvé cette formule  $\frac{1}{m^n} \times$   
 $\times \frac{m-1}{m-1} a + \frac{A-n}{m-1} b + \frac{B-n \cdot \frac{n-1}{2}}{m-1} c + \frac{C-n \cdot \frac{n-1}{2} \cdot \frac{n-2}{3}}{n-1} d$

"  $+\&c.$  ou les Lettres  $A, B, C, \&c.$  marquent  
 " les

“ les Coefficients des termes immédiatement prece-  
 “ dents. Et en mettant dans cette formule  $p + 1$   
 “ pour  $n$ ,  $b^m$  pour  $m$ , & en multipliant tout encore  
 “ par  $e^{m-1}$ , on a la solution de vostre *Prob.*  
 “ IX<sup>m</sup>”. Et me monuit Vir peritissimus hanc suam  
 formulam generalem in nostram particularem (*Cor. 1.*  
 hujus propositionis) migrare quando  $n = \infty$ ; quippe  
 tum evanescunt  $1, n, n \cdot \frac{n-1}{2}, n \cdot \frac{n-1}{2} \cdot \frac{n-2}{3}, \&c$  res-  
 pectu ipsorum  $m^n, A, B, C, \&c$ . adeo ut Series in eo  
 casu sit  $\frac{1}{m-1} a + \frac{A}{m-1} b + \frac{B}{m-1} c + \&c$ . quæ om-  
 nino coincidit cum nostrâ  $\frac{a}{m-1} + \frac{b}{m-1}, + \frac{c}{m-1}, +$   
 $\&c$ .

Adhuc aliam hujus Problematis solutionem, & quidem  
 ab hisce admodum diversam, invenit D. *Taylor* ope  
 Methodi suæ Incrementorum. Viri doctissimi rogatu,  
 ad eum miseram formulam meam secundam pro solu-  
 tione Problematis II<sup>di</sup>, item formulas alias spectantes ad  
 Propositiones tertiam, quartam & quintam, sed sine de-  
 monstrationibus: quippe non dubitabam quin Vir acu-  
 tissimus, atque ipse Methodi istius Incrementorum In-  
 ventor, hisce, vel saltem paribus inveniendis par esset.  
 Rescripsit se harum solutiones invenisse, & simul alia  
 quædam communicavit ad hujus methodi profectum  
 multum facientia, quæ jam nostro hortatu inductus hisce  
 subjungere dignatur.

# A P P E N D I X

*Quâ methodo diversâ eadem materia tractatur :*  
*Auctore Brook Taylor, LL. D. R. S. Secr.*

**H**ortatu Viri Clariss. cui nos innumeris officiis devinctissimos esse libenter fatemur, sequentes jam Propositiones exhibemus, quas quidem in aliam occasionem reservandas esse decrevissemus, ni æquum visum fuisset parendum esse imperio amici qui, dum Propositiones quasdam præcedentes suas olim nobis investigandas proposuit, earum inveniendarum occasionem dedit.

## *Definitiones.*

1. Quantitatis cujusvis variabilis valorem præsentem designo literâ simpliciter scriptâ, ut  $x$  ; valores præcedentes distinguo lineolis eidem literæ ex parte superiori positis, sequentes lineolis ex parte inferiori scriptis.

Ut vi hujus Definitionis sint  $x''$ ,  $x'$ ,  $x$ ,  $x$ ,  $x$ , ejusdem variabilis valores quinque continui, existente  $x$  valore præsentem,

$x'$  proximè præterito,  $x''$  secundò præterito ;  $x$  proximè, atque  $x$  secundò futuro. Et sic de aliis.

Ad eundem modum sunt interpretandæ lineolæ quæ

incrementis apponuntur. Sic sunt  $x''$ ,  $x'$ ,  $x$ ,  $x$ ,  $x$ , ip-

sius  $x$  valores quinque continui ; ut sit  $x''$  incrementum secundum

secundum ipsius  $x$ , sit  $\dot{x}$  incrementum secundum ipsius

$x$ . Et sic de aliis.

*Cor.* Vi hujus Definitionis,  $x + \dot{x} = x$ ,  $x + \ddot{x} = y$ ,

$x + \ddot{x} = x$ . Et sic de aliis hujusmodi.

Quando usu venit ut variabilis quantitas, puta  $x$ , spectanda sit tanquam Incrementum, ejus Integrale designo literâ inter uncas [ ] inclusâ. Illius etiam Integralis [  $x$  ] Integrale (vel ipsius  $x$  Integrale secundum,) designo numero binario uncorum priori superimposito,

ut  $[\dot{x}]$ . Illius etiam Integralis Integrale (vel ipsius  $x$  Integrale tertium,) ad eundem modum designo numero

ternario, ut  $[\ddot{x}]$ . Et sic deinceps. Unde vi hujus

Definitionis constituunt  $[\ddot{x}]$ ,  $[\dot{x}]$ ,  $[x]$ ,  $x$  Seriem terminorum, quorum quilibet est ipsum immediatè præcedentis incrementum primum, ut sit  $[\ddot{x}] = [\dot{x}]$ ,

$[\dot{x}] = [x]$ ,  $x = [x]$ .

#### *Lemma.*

Facti  $x$  &  $v$  ex Multiplicatione duorum variabilium  $x$  &  $v$ , incrementum est  $xv + \dot{x}v$ .

Nam auctis variabilibus per propria incrementa, sit novum productum  $x + \dot{x} \times v + \dot{v}$ , sive  $xv + \dot{x}v + x + \dot{x} \times v$ , hoc est  $xv + \dot{x}v + x + \dot{x}v$  (pro  $x + \dot{x}$  scripto  $x$  per Def. 1.)

Unde dempto priori producto  $xv$ , restat Incrementum  $\dot{x}v + x\dot{v}$ .

Qq q q q

*Prop.*

*Prop. I. Theor.*

Ejusdem Facti  $xv$  Incrementum, vel primum, vel secundum, vel tertium, vel aliud quodvis, cujus ordo designatur per symbolum  $n$ , exhibetur per formulam hanc generalem

$$\begin{aligned} & \underset{n}{x} \underset{n-1}{v} + \underset{n-1}{x} \underset{n-2}{v} + n \times \frac{n-1}{2} \underset{n-2}{x} \underset{n-2}{v} + n \times \frac{n-1}{2} \times \frac{n-2}{3} \\ & \underset{n-3}{x} \underset{n-3}{v} + \text{etc.} \end{aligned}$$

In hac formulâ hæc sunt observanda, 1<sup>mo</sup> Terminorum numeri coefficientes 1,  $n$ ,  $n \times \frac{n-1}{2}$ ,  $n \times \frac{n-1}{2} \times \frac{n-2}{3}$  &c. iidem sunt ac in binomii dignitate  $n$ . 2<sup>do</sup> Numeri  $n$ ,  $n-1$ ,  $n-2$ ,  $n-3$ , &c. ipsis  $x$  infra scripti designant numeros punctorum quibus definiuntur Incrementa. 3<sup>io</sup> Lineolæ „ „ „ „ &c. ipsis  $x$  infra scriptæ, interpretandæ sunt per Def. 1 4<sup>to</sup>. In quovis Termino numerus punctorum ipsis  $x$  &  $v$  simul infra scriptorum, est  $n$ . Sit v.g.  $n=4$ : tum per formulam, ipsius  $xv$  incrementum quantum prodit  $xv + 4 \underset{1}{x} \underset{1}{v} + 6 \underset{2}{x} \underset{2}{v} + 4 \underset{3}{x} \underset{3}{v} + \underset{4}{x} \underset{4}{v}$ .

Theorema hoc generale demonstrari potest per Inductionem, incrementis continuò sumptis juxta formam in Lemmate præcedenti traditam. Sed & collectâ formâ Series ex hujusmodi calculo, Theorema etiam demonstrari potest per Methodum Incrementorum, ad eum modum cujus specimen mox dabimus in demonstratione Propositionis tertiæ.

*Prop. II. Theor.*

Ipsius  $xv$  Integrale primum  $[xv]$  exhibetur per Seriem  $[x]v - [\underset{1}{x}] \underset{1}{v} + [\underset{2}{x}] \underset{2}{v} - [\underset{3}{x}] \underset{3}{v} + \text{etc.}$

Series autem ita terminatur, ut sit  $[xv] = [x]v$

$$- [\dot{x}] \dot{v} = [x] v - [\dot{x}] \dot{v} + \left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v} = 0.$$

Nam sumendo incrementa restituitur propositum  $xv$ .

*Cor. 1.* Datis duobus ex istis  $[x]$ ,  $[xv]$ ,  $\left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v}$ ,

datur tertium. Item datis tribus ex istis  $[x]$ ,  $\left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v}$ ,  $[xv]$ ,  $\left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v}$ , datur quartum, Et sic porro.

*Cor. 2.* Si  $\dot{v} = 0$ , datur  $[xv]$  ex dato  $[x]$ . Si  $\dot{v} = 0$  datur  $[xv]$  ex datis duobus  $[x]$ , &  $\left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v}$ , Si  $\dot{v} = 0$ , datur  $[xv]$ , ex datis tribus  $[x]$ ,  $\left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v}$ ,  $\left[ \begin{smallmatrix} 3 \\ x \end{smallmatrix} \right] \dot{v}$ . Et sic porro.

*Ex. 1.* Sit exemplum hujus formulæ in inventione Integralis ipsius  $\frac{v}{z z z z}$ , dato nempe  $z$ , atque existente

$\dot{v} = 0$ , qui casus est specialis Propositionis secundæ Tractatus præcedentis D<sup>ni</sup> Monmort. Facto itaque  $x =$

$$\frac{1}{z z z z}, \text{ sunt } [x] = \frac{-1}{3 z z z z}, \left[ \begin{smallmatrix} 2 \\ x \end{smallmatrix} \right] \dot{v} = \frac{1}{2 z \times 3 z z z},$$

$$\text{atque } \left[ \begin{smallmatrix} 3 \\ x \end{smallmatrix} \right] \dot{v} = \frac{-1}{1 z \times 2 z \times 3 z z}.$$
 Unde per formulam

$$\text{fit } [xv], \text{ hoc est } \left[ \frac{v}{z z z z} \right] = - \frac{v}{3 z z z z} =$$

$$- \frac{v}{2 z \times 3 z z z} - \frac{v}{1 z \times 2 z \times 3 z z}.$$

*Ex.*

*Ex. 2.* Sit aliud exemplum in inventione Integralis ipsius  $na^z$ , ubi est  $z=1$ , atque datur  $a$ , Tum pro  $x$  sumpto  $a^z$ , & pro  $v$  sumpto  $n$ , sit  $x=a^z$ , hoc est  $x=ax$ , seu  $x - x = ax$ , adeoque  $x = a - 1$ ,  $x$ ,

atque  $x = \frac{x}{a-1}$ . Regrediendo itaque ad Integralia fit

$[x] = \frac{x}{a-1}$ ; item  $[\dot{x}] = \frac{[x]}{a-1} = \frac{x}{a-1^2}$ , item  $[\ddot{x}] = \frac{[\dot{x}]}{a-1} = \frac{x}{a-1^3}$ ; & sic porro. Adeoque (quoniam  $x = ax$ ) sunt

$[x] = \frac{x}{a-1}$ ,  $[\dot{x}] = \frac{ax}{a-1^2}$ ,  $[\ddot{x}] = \frac{a^2x}{a-1^3}$ , &c. Unde

per formulam prodit  $[na^z] = \frac{a^z n}{a-1} - \frac{a^{z+1} n}{a-1^2} + \frac{a^{z+2} n}{a-1^3}$  &c.

In hoc exemplo continetur Solutio Problematis, de quo agit D<sup>us</sup> de *Monmort* in Propositione nona. Coincidit autem formula cum ea quam exhibet ille in Corollario primo ejusdem Propositionis.

*Scholium.* Possunt etiam ex hac formulâ alii derivari valores Integralis quæfiti, pro vario modo quo interpretantur Incrementi propositi factores. Sic in exemplo secundo integrale ipsius  $na^z$  exhiberi potest per

formulam  $a^z[n] = \frac{1}{a-1} a^z[\dot{n}] + \frac{1}{a-1^2} a^z[\ddot{n}]$

— &c. pro  $x$  nempe sumpto  $n$ , & pro  $v$  sumpto  $a^z$ . Sed de his fortasse aliâ occasione fusius dicemus.

### *Prop. III. Theor.*

Ejusdem  $xv$  Integrale, vel primum, vel secundum, vel tertium, vel aliud quodvis cujus ordo designatur symbolo  $n$ , exhibetur per Seriem in hac formâ generali prodeuntem  $[xv] = [x]v - n[\dot{x}]v + \frac{n+1}{2}[\ddot{x}]v - \frac{n+1}{6}[\ddot{\ddot{x}}]v + \dots$

— &c.

$$+ n \times \frac{n+1}{2} \left[ \begin{smallmatrix} x \\ '' \end{smallmatrix} \right] v - n \times \frac{n+1}{2} \times \frac{n+2}{3} \left[ \begin{smallmatrix} x \\ ''' \end{smallmatrix} \right] v + \&c.$$

Collectâ formâ Seriei ex Propositione præcedenti, Coefficientes 1, —  $n$ ,  $n \times \frac{n+1}{2}$ , —  $n \times \frac{n+1}{2} \times \frac{n+2}{3}$ , &c. sic inveniuntur per Methodum Incrementorum. Pone  ${}^n [xv] = A[{}^n x]v + B[{}^{n+1} x]v + C[{}^{n+2} x]v + D[{}^{n+3} x]v + \&c.$

Tum aucto  $n$  incremento suo  $n = 1$ , atque ipsis  $A, B, C, D, \&c.$  incrementis suis contemporaneis  $A, B, C, D, \&c.$  ut jam evadant  ${}_1 n, {}_1 A, {}_1 B, {}_1 C, {}_1 D, \&c.$  fiet novum

$$\text{Integrale (quod Integrale est ipsius } [xv],) [xv] = {}^{n+1} A[{}^n x]v + {}^{n+2} B[{}^{n+1} x]v + {}^{n+3} C[{}^{n+2} x]v + {}^{n+4} D[{}^{n+3} x]v + \&c. \text{ Hujus}$$

itaque Incrementum primum coincidere debet cum Integrali prius posito. Sumptis ergo incrementis, fit  ${}^n [xv] = A[{}^n x]v + {}_1 A[{}^{n+1} x]v + {}_1 B[{}^{n+2} x]v + {}_1 C[{}^{n+3} x]v + {}_1 B[{}^{n+1} x]v + {}_1 C[{}^{n+2} x]v + {}_1 D[{}^{n+3} x]v +$

idem ac Integrale prius positum. Itaque terminos homologos inter se comparando fit 1<sup>mo</sup>  $A = A$ . Unde est

$A$  datum quid. Sed ubi  $n = 0$ , est  $A = 1$ , ergo  $A = 1$ . 2<sup>do</sup>  $B = B + A$ , hoc est  $B = B + B + 1$ , seu

$B = -1 = -n$ . Ergo regrediendo ad Integralia, fit  $\dot{B} = -n + a$ . Sed ubi  $n = 0$ , est  $B = 0$ . Ergo  $a = 0$ , atque  $B = -n$ . 3<sup>io</sup>  $C = C + B$ , hoc est  $C = \frac{n}{2}$ . Regre-

K r r r r

diendo



diendo itaque ad Integralia fit  $C = \frac{n^n}{2} + b$ . Sed ubi

$n = 0$ , est  $C = 0$ . Ergo  $b = 0$ , atque  $C = \frac{n^n}{2}$ , hoc est,

$n \times \frac{n+1}{2}$ . 4<sup>ta</sup>. Ad eundem modum invenitur  $D = -n$

$\times \frac{n+1}{2} \times \frac{n+2}{3}$ . Et sic pergendo inveniuntur ceteri Coefficientes.

*Scholium. I.* In hac Propositione comparatâ cum Propositione primâ, cernitur singularis quâdam relatio Incrementa inter & Integralia. Ut enim in Arithmeticâ vulgari, Multiplicatio & Divisio sunt invicem ita contrariæ, ut si Multiplicatio designetur per Indicem affirmativum, Divisio designabitur per Indicem cum signo negativo; sic etiam in Methodo Incrementorum, si Incrementum designetur per Indicem affirmativum, Index negativus Integrale sistet. Sic in Propositione primâ, si pro  $n$  sumatur Numerus binarius 2, per formulam exhibebitur ipsius  $xv$  incrementum secundum, nempe  $xv + 2 \times v + xv$ ; Sed si pro  $n$  sumatur nume-

rus negativus  $-2$ , ut jam quæraturs ipsius  $xv$  incrementum (ita loqui liceat) negativè secundum, (quod idem est ac Integrale secundum) prodeunt coefficientes iidem ac si sumatur  $n$  affirmativè in Propositione præsentî: atque interpretatis insuper ipsis  $x$ ,  $x$ ,  $x$ , &c. per  ${}^2[x]$ ,  ${}^3[x]$ ,  ${}^4[x]$ , &c. Series fit omnino eadem ac

per Propositionem præsentem prodit, ubi quæritur Integrale secundum.

2. Ex his autem formulis quasi suâ sponte procedunt formulæ Propositionum undecimæ atque duodecimæ Libri de Methodo Incrementorum. Nam pro incre-

incrementis scribe Fluxiones, atque evanescentibus incrementis fiant jam omnes  $x, x, x, x, \&c.$  inter se æ-

quales, atque migrabit statim hæc Propositio secunda in illam undecimam, atque præcens tertia in illam quoddecimam. Quod quidem exemplum satis inigne est Methodi *Newtoniana*, quâ colligit ille rationes Fluxionum ex rationibus ultimis Incrementorum evanescentium, vel ex primis nascentium.

## *Additamentum.*

**P**Ræcedentium impressioni intentus dum Typothetarum erroribus corrigendis do operam, atque eâ occasione in animo illa sæpius revolve, subiit Artificium illud quo jam olim usus est D. *Jac Bernoulli* in inventionem quarundam Serierum, opè Progressionis Harmonicæ cujus meminit D. de *Momort* in *Scholio 6. Prop. V.* præcedente commodè etiam applicari posse ad inventionem ipsius *Momortii* Propositionum  $2^{da}, 3^{tia}, 4^{ta}, 5^{ta}$ , atque id genus aliarum aliquanto fortasse generaliorum. Hoc in sequentibus paucis ostendisse, credebam Lectori non fore ingratum.

### *Theorema.*

Sit Progressio Arithmetica  $p, p + n, p + 2n, \&c.$  cujus termini singuli successive designentur per  $x, \&c.$  sunt  $b, c, d, \&c.$  quivis multiplices differentie datæ  $n$  terminorum Progressionis istius Arithmeticæ. Sint  $A, B, C, D, \&c.$  Numeri quilibet dati, & constituantur fractiones quovis  $\frac{A}{x}, \frac{B}{x+b}, \frac{C}{x+c}, \frac{D}{x+d}, \&c.$  Pro successive scriptis valoribus suis  $p, p + n, p + 2n, \&c.$

ex harum fractionum quâlibet, oritur Series Harmonicæ proportionalium Sic *v g.* ex fractione primâ  $\frac{A}{p}$ ,

oritur Series  $\frac{A}{p}, \frac{A}{p+n}, \frac{A}{p+2n}, \&c.$  Dico quod aggregatum quotlibet hujusmodi Serierum in infinitum continuatarum in terminis numero finitis exhiberi potest, si modo fuerit numeratorum  $A, B, C, D, \&c.$  aggregatum æquale nihilo. Duobus exemplis hoc fiet manifestum.

*Ex.* Sint duæ tantum fractiones  $\frac{A}{x}$ , atque  $\frac{-A}{x+3n}$ , existente  $b=3n$ . Scribantur Series harmonicæ ex his formulis ortæ, eo ordine, ut termini, in quibus sunt denominatores æquales, sibi invicem respondeant, & collectis summis terminorum homologorum, prodibit aggregatum Serierum in terminis numero finitis, ut in calculo apposito videre est.

$$\begin{array}{l} \frac{A}{p} + \frac{A}{p+n} + \frac{A}{p+2n} + \frac{A}{p+3n} + \frac{A}{p+4n} + \&c. = \text{Series ortæ ex } \frac{A}{x} \\ \quad + \frac{-A}{p+3n} + \frac{-A}{p+4n} + \&c. = \text{Series ex } \frac{-A}{x+3n} \\ \hline \frac{A}{p} + \frac{A}{p+n} + \frac{A}{p+2n} + 0 + 0 + \&c. = \text{Aggreg. Serierum.} \end{array}$$

*Ex. 2.* Sint tres fractiones  $\frac{A}{x}, \frac{B}{x+2n}, \frac{C}{x+3n}$ , existentibus  $b=2n, c=3n$ , atque  $A+B+C=0$ . In hoc casu Calculus sic se habet.

$$\begin{array}{l} \frac{A}{p} + \frac{A}{p+n} + \frac{A}{p+2n} + \frac{A}{p+3n} + \dots + \&c. = \text{Series ortæ ex } \frac{A}{x} \\ \quad + \frac{B}{p+2n} + \frac{B}{p+3n} + \dots + \&c. = \text{Series ex } \frac{B}{x+2n} \\ \quad + \frac{C}{p+3n} + \dots + \&c. = \text{Series ex } \frac{C}{x+3n} \\ \hline \frac{A}{p} + \frac{A}{p+n} + \frac{A+B}{p+2n} + \frac{A+B+C=0}{p+3n} + \&c. = \text{Aggregato Serierum.} \end{array}$$

Ubi

Ubi etiam prodit aggregatum Serierum in terminis numero finitis, nempe  $\frac{A}{p} + \frac{A}{p+n} + \frac{A+B}{p+2n}$ , ob Numeratorum  $A, B, C$ , aggregatum æquale nihilo. Et ad eundem modum demonstratur Theorema in aliis casibus quibuscumque.

*Cor. I.* Ex his principiis derivari possunt innumeræ Series in infinitum continuatæ, in terminis tamen numero finitis summabiles.

*Cas. I.* Sint  $\frac{A}{x}$  &  $\frac{-A}{x+b}$  formulæ duarum Serierum harmonicarum quarum aggregatum prodit in terminis numero finitis per superius demonstrata, Tum, formulis istis in unam summam collectis, fit  $\frac{Ab}{x \times x + b}$  formula

Seriei summabilis. Sint *v. gr.*  $A = \frac{1}{6}$ ,  $p = 1$ ,  $n = 2$ , atque  $b = 3n = 6$ . Tum formulæ Serierum harmonicarum erunt  $\frac{1}{6x}$ , &  $\frac{-1}{6 \times x + 6}$ , formula Seriei compositæ

summabilis erit  $\frac{1}{x \times x + 6}$ , Serie illa existente  $\frac{1}{1 \times 7}$

$+\frac{1}{3 \times 9} + \frac{1}{5 \times 11} + \frac{1}{7 \times 13} + \text{etc.}$  atque summa Seriei, per

calculum in præmissis demonstratum, erit  $\frac{1}{6 \times 1} + \frac{1}{6 \times 3}$

$+\frac{1}{6 \times 5}$ . Sint tres formulæ Serierum harmonicarum

$\frac{A}{x}$ ,  $\frac{B}{x+b}$ ,  $\frac{C}{x+c}$ , (existente  $A+B+C=0$ , ut fit Serierum aggregatum finitum per præmissa.) Tum formulis in unam summam collectis fit

$\frac{A \times x + b \times x + c + B \times x \times x + c + C \times x \times x + b}{x \times x + b \times x + c}$ , seu (terminis revocatis ad formam factorum  $x$ ,  $x \times x + b$ ,

$x \times x + b \times x + c$ .)

$\frac{Acb + Ac + c - bB \times x + A + B + C \times x \times x + b}{x \times x + b \times x + c}$ , hoc est

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(ob  $A + B + C = 0$ )  $\frac{Acb + Ac + B \times c - b \times x}{x \times x + b \times x + c}$ , formula Seriei summabilis. Si quatuor sint Fractiones  $\frac{A}{x}, \frac{B}{x+b}, \frac{C}{x+c}, \frac{D}{x+d}$ , (existente  $A + B + C + D = 0$ ) ad eundem modum invenietur formula Seriei summabilis

$$\frac{Abcd + Acd + B \times c - b \times d - b \times x + Ad + B \times d - b \times c + C \times d - c \times x \times x - b}{x \times x + b \times x + c \times x + d}$$

Et sic pergere licet ad formulas adhuc magis compositas.

*Caf. 2.* Et si plures sint formulae Serierum huiusmodi summabilium, quarum denominatorum factores excerpantur ex diversis progressionibus Arithmeticis, ex istarum formularum quotvis in unam summam additione, conficietur formula nova Seriei summabilis:

Sint e. gr. formulae duae Serierum summabilium  $\frac{1}{x \times x + 3}$

&  $\frac{1}{x \times x + 2}$ , excerptis  $x$  ex Progressione Arithmetica 1,

2, 3, 4, &c.  $z$  ex Progressione Arithmetica 1, 3, 5, &c. Tum ex his formulis in unam summam collectis

fiet formula nova  $\frac{x \times x + 2 + x \times x + 3}{x \times x + 3 \times x \times x + 2}$ , vel, (exposi-

to  $z$  per  $x$  & numeros datos)  $\frac{2x - 1 \times 2x + 1 + x \times x + 3}{x \times x + 3 \times 2x - 1 \times 2x + 1}$

*Cor. 2.* Hinc omnis Series in infinitum continuata summabilis est, cujus termini designantur per Fractionem, cujus denominatoris factores excerpuntur ex data quâlibet Progressione Arithmetica, numerator autem est multinomium, cujus dimensiones sunt ad minimum binario pauciores, quam sunt dimensiones Denominatoris. Nam omnis huiusmodi fractio resolvi potest in tot fractiones simplices, quot sunt dimensiones (hoc est, quot sunt factores) Denominatoris, quarum numeratorum aggregatum est nihil. Sit exempli gratia, formula

formula oblata  $\frac{\alpha + \beta x + \gamma x \times x + b}{x \times x + b \times x + c \times x + d}$ . Pone hanc for-

mulam aequari aggregato fractionum  $\frac{A}{x} + \frac{B}{x+b} + \frac{C}{x+c}$   
 $+ \frac{D}{x+d}$ . Tum fractionibus istis in unam summam collectis

fiet  $\frac{A b c d + A c d + B c - b \times d - b \times x}{x \times x + b \times x + c \times x + d} + \frac{A d + B \times d - b + c \times d - c \times x \times x + b}{x \times x + b \times x + c \times x + d} + \frac{A + B + C + D \times x \times x + b \times x + c}{x \times x + b \times x + c \times x + d} = \frac{\alpha + \beta x + \gamma x \times x + b}{x \times x + b \times x + c \times x + d}$  applicatum ad

Unde per comparationem terminorum homologorum  
 fit  $A b c d = \alpha$ ,  $A c d + B \times c - b \times d - b = \beta$ ,  $A d + B$   
 $\times d - b + C \times d - c = \gamma$ ,  $A + B + C + D = 0$ .  
 adeoque  $A = \frac{\alpha}{b c d}$ ,  $B = \frac{\beta - A c d}{c - b \times d - b^2}$

$C = \frac{\gamma - A d - B \times d - b}{d - c}$ ,  $D = -A - B - C$ , Quo pacto

formula oblata resolvitur in fractiones simplices  $\frac{\alpha}{b c d x}$

$+ \frac{\beta - A c d}{c - b \times d - b \times x + b} + \frac{\gamma - A d - B \times d - b}{d - c \times x + c}$

$+ \frac{-A - B - C}{x + d}$ , ex quibus ortarum Serierum ag-

gregatum, hoc est, summa Seriei ortæ ex formulâ ob-

latâ  $\frac{\alpha + \beta x + \gamma x \times x + b}{x \times x + b \times x + c \times x + d}$ , per jam dicta prodit

in terminis numero finitis. Quod verò dimensiones  
 numeratori in formulâ oblata, debeant esse binario ad  
 minimum pauciores, quam sunt dimensiones Denomi-

natoris, hinc constat quod in reductione fractionum  
 $\frac{A}{x} + \frac{B}{x+b} + \frac{C}{x+c} + \frac{D}{x+d}$ , quilibet numerator  $A, B, C, D$ ,

ducitur

ducitur in omnes denominatores excepto uno, nempe suo ; unde prodeunt Numeratoris Dimensiones unitate pauciores quam sunt dimensiones Denominatoris. Sed per æquationem  $A + B + C + D = 0$  perit altissima dimensio in numeratore ; Unde supersunt Numeratoris Dimensiones ad minimum binario-pauciores quam sunt dimensiones Denominatoris. Ad hoc verò Corollarium revocari possunt D. de Monmort Propositiones 2<sup>da</sup> & 5<sup>ta</sup>.

Cor. 3. Item oblata formulâ juxta *Cas. 2. Cor. 1.* adhuc magis compositâ, ex iidem principiis perspici potest an sit Series summabilis. Sint progressionēs duæ Arithmeticæ 1, 3, 5, &c. 2, 4, 6, &c. quarum termini homologi designentur per  $x$  &  $z$ , & sit formula Seriei oblata  $\frac{\alpha + \beta x + \gamma x^2}{x \times x + 1 \times x + 2 \times x + 3}$ , vel (pro  $z$  scripto  $x + 1$ , & factoribus Denominatoris in ordinem coactis)  $\frac{\alpha + \beta x + \gamma x^2}{x \times x + 1 \times x + 2 \times x + 3}$ . Pone formu-

lam hanc æquari aggregato formularum  $\frac{P}{x \times x + 2}$ ,

$\frac{Q}{x + 1 \times x + 3}$ , Serierum per superius dicta summabilium, ut (formulis his novissimis in unam summam collectis) sit  $\frac{P \times x + 1 \times x + 3 + Q \times x \times x + 2}{x \times x + 1 \times x + 2 \times x + 3}$  seu

$$\frac{3P + 4P + 2Q + P + Qx^2}{x \times x + 1 \times x + 2 \times x + 3} = \frac{\alpha + \beta x + \gamma x^2}{x \times x + 1 \times x + 2 \times x + 3}.$$

Hinc comparando terminos homologos oriuntur æquationes  $3P = \alpha$ ,  $4P + 2Q = \beta$ ,  $P + Q = \gamma$ . Unde eliminati  $P$  &  $Q$  per debitas operationes Analyticas, prodit æquatio  $2\alpha - 3\beta + \gamma = 0$ , qua definitur relatio quæ inter coefficientes  $\alpha$   $\beta$   $\gamma$  intercedere debet,

ut Series orta ex formulâ oblata  $\frac{\alpha + \beta x + \gamma x^2}{x \times x + 1 \times x + 2 \times x + 3}$  sit

fit summabilis. Ad eundem modum si formulæ oblatæ Denominatoris factores excerpantur ex tribus Progressionibus Arithmeticis, inveniuntur duæ æquationes quibus definiantur relationes coefficientium Numeratoris, ut fit Series summabilis. Si quatuor sint Progressiones Arithmeticæ, Coefficientium relatio definitur per tres æquationes. Et sic porro. Et in hujusmodi formulis ut sint Series summabiles, hæc insuper observanda sunt, Primò ut Numeratorum dimensiones sint ad minimum binario pauciores quam sunt dimensiones Denominatorum, Deinde ut ex singulis Progressionibus Arithmeticis excerpantur ad minimum duo factores Denominatoris. Denique, quod si sint duo vel plures factores Denominatoris inter se æquales, ponendum sit tot etiam Progressiones Arithmeticas, ex quibus excerpuntur, esse inter se æquales. Præmissis attentius perpensis, hæc obvia erunt. Ad hoc vero Corollarium facile revocantur D. de *Monmort* Propositiones 3<sup>ta</sup> & 4<sup>ta</sup>.

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## E I N I S.

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### ERRATUM in N<sup>o</sup>. 352.

**P**Age 586, after the end of line 15, add *black Cloud, from behind which there issued a.*

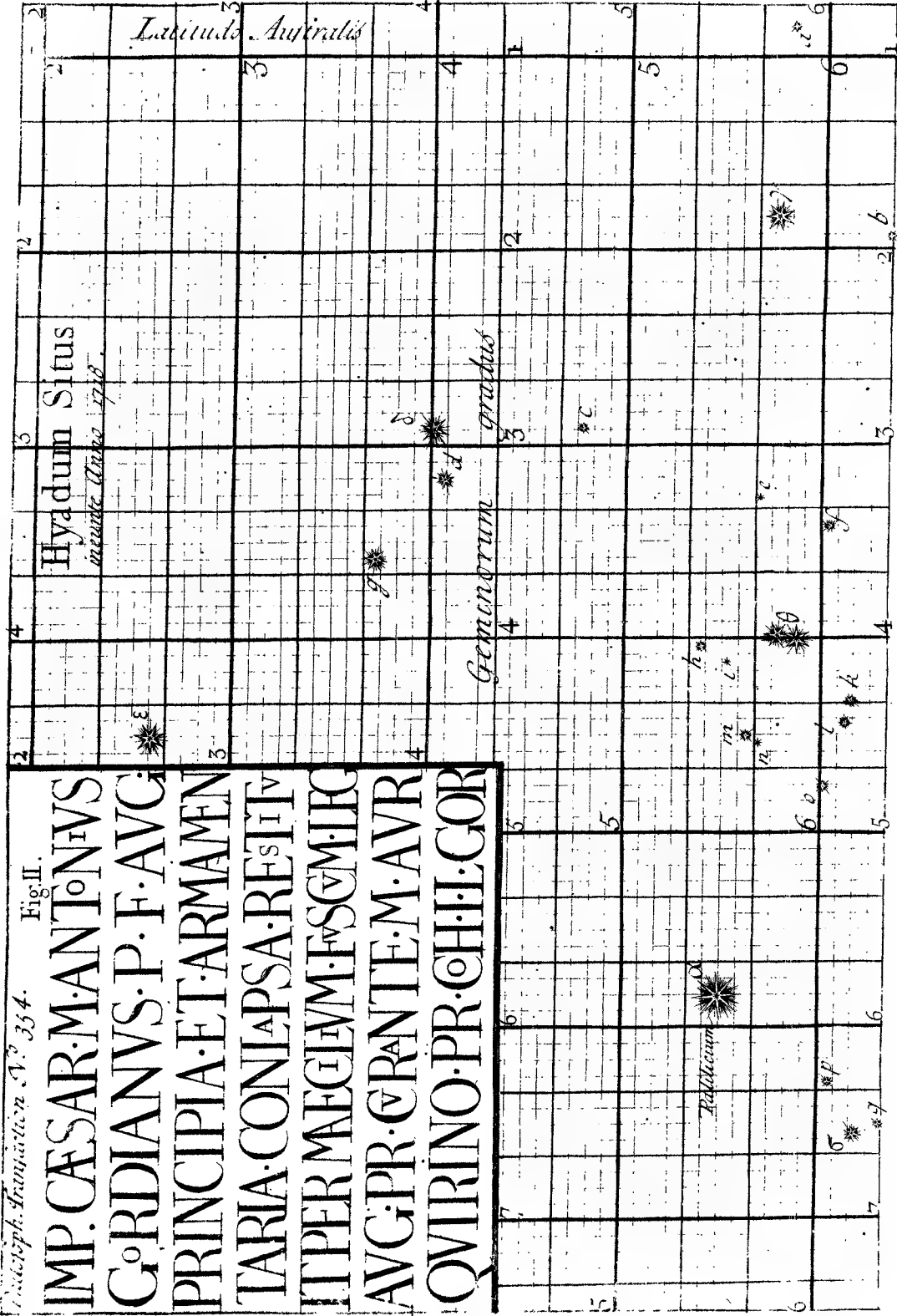
### L O N D O N:

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1717.



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# PHILOSOPHICAL TRANSACTIONS,

For the Months of *Octob.* *Nov.* and *Decemb.* 1717.

## The C O N T E N T S.

- I. *An Advertisement to Astronomers, of the Advantages that may accrue from the Observation of the Moon's frequent Appulses to the Hyades, during the three next ensuing Years.*
- II. *Solutio Problematis à Dom. G. G. Leibnitio Geometris Anglis nuper propositi. Per Brook Taylor, LL. D. & R. S. Secr.*
- III. *Extract of a Letter of Dr. Chr. Hunter, M.D. to Dr. J. Woodward, M.D. & R. S. S. from Durham, giving an Account of a Roman Inscription, lately dug up in the North of England; with some Historical and Chronological Remarks thereon.*
- IV. *A new Genus of P L A N T S, call'd Araliastrum, of wh. ch the famous Nin-zin or Ginseng of the Chinese, is a Species. Communicated by Mr. Vaillant Prædemonstrator at the Royal Garden at Paris, to the Learned Dr. Will. Sherrard, LL. D. late Consul at Smyrna, and by him to the Royal Society.*
- V. *Extract of a Letter of Mr. Edw. Berkley from Naples, giving several curious Observations and Remarks on the Eruptions of Fire and Smoak from Mount V E S U V I O. Communicated by Dr. John Arbuthnot, M. D. and R. S. S.*
- VI. *An Account of an extraordinary Tumour or Wen lately cut off the Cheek of a Person in Scotland. Communicated to the Royal Society by Dr. Thomas Bower, M. D. and F. R. S.*
- VII. *An Account of an Experiment to prove an interpos'd Vacuum; or to shew that all Places are not equally full. By the Reverend J. Theoph. Desaguliers, M. A. and R. S. S.*

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VIII *An Account of a small Telescopical Comet seen at London on the 10th of June 1717. by Edm. Halley, L.L. D. R. Soc. Secr.*

IX *An Account of Books: I. Joannis Poleni in Gymnasio Patavino Phil. Ord. Prof. & Scient. Societatum Regalium, quæ Londini & Berolini sunt, Sodalis, De Mtu Aquæ mixto, Libri duo, &c. 4<sup>to</sup>. Patavii 1717. II. Apollonii Pergæi Conicorum Libri Octo & Sereni Antisthenis de Sectione Cylindri & Coni Libri duo. Fbl. Reg. E Theatro Oxon. 1710.*

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### I. *An Advertisement to Astronomers, of the Advantages that may accrue from the Observation of the Moon's frequent Appulses to the Hyades, during the Three next ensuing Years.*

**O**F all the Methods hitherto proposed for finding the *Longitudes* of Places for Geographical Uses, none seems more adapted to the purpose, than that by the *Occultations* of the fixt Stars by the *Moon* observed in distant Parts: For those Immersions of the Stars which happen on the dark Semicircle of the Moon, and their Emissions from the same, are perfectly momentaneous, without that Ambiguity, to which the Observations of the Eclipses of the *Moon* and those of *Jupiter's Satellites* are subject. Besides, whilst the Moon is horned, and her weaker Light less dazzling, an ordinary short Telescope, such as by Experience is found to be manageable on Ship board, suffices to observe those Moments, even in the Occultations of very minute Stars: On which account, this way seems to bid fairest for the desired Solution of the grand Problem of finding the Longitude at Sea. But since it would be needless to enquire exactly what Longitude a Ship is in, when that of the Port to which she is bound is still unknown, it were to be wisht that the Princes of the Earth would cause such Observations to be made, in the Ports and on the principal Head-Lands of their Dominions, each for his own, as might

might once for all settle truly the Limits of the Land and Sea. This Work however being likely to be left to the Care and Curiosity of private Persons, it may not be amiss hereby to give notice of the present Opportunity of performing it, in this our Northern Hemisphere, by help of the frequent Appulses of the Moon to the more Southerly of the *Hyades*, many of which she eclipses in each monthly Revolution, and will continue so to do, during the Years 1718, 1719, and 1720.

These Stars are but Three or Four in all former Catalogues, but the *British* of Mr *Flamsteed* encreases them to Sixteen; to them we have added Three others somewhat smaller, *viz.* *c*, *i*, and *n* in the Figure of the *Hyades* here-to annexed. In it the principal Stars are markt with *Bayer's* Marks, and the rest with the Letters of the *Italic* Alphabet; their Longitudes are fitted to the beginning of the Year 1718, and being truly laid down, may serve to instruct the curious Observer, when and where to look for them, when the Moon is among them.

It appears by this Scheme that the Distance between *a* and *α* or *Palilicium*, is about Nine Hours Motion of the Moon, in which time supposing her to pass from one to the other, she must eclipse *γ* and *e*, and Four or Five of those about *θ*, and must apply very close with her Southern Limb, to all those which have about Six Degrees South-Latitude; which would be a very entertaining Sight for the Lovers of these Arts. But if the Times of the Occultations of any One of these Stars, or even of any Two of them in the same Night, be accurately observed under distant Meridians, the difference of those Meridians may be truly obtain'd thereby; especially since the *Moon's* *Parallax*, and all other parts of her Theory thereto required, are at present sufficiently stated and known.

For the sake of such as are willing to make use of this Method, we have added the Places of all the *Hyades* fitted to the present Time, and chiefly taken from the *British* Catalogue, which being faulty in the Stars we call *k* and *l*, we have here rectified them.

## Catalogus Hyadum, ineunte Anno 1718.

Stellarum NOMINA.		Long. II	Lat. Aufl.	Ma.
<i>Quae praecedit <math>\gamma</math> Tauri</i> ——— a	0	51 35	50 14	7
<i>In naribus Tauri, Bayero</i> $\gamma$	1	50 54	5 46	22 3
<i>Quae sub <math>\gamma</math></i> ——— b	1	56 31	6 19	57 7
<i>In Origine Nasi Tauri</i> ——— c	2	54 25	4 47	5 7
<i>Inter nares &amp; oculum Tauri</i> } $\delta$	2	54 47	4 0	34 3
<i>Boreum</i> ——— ——— }				
<i>Huic contigua ad Austrum.</i> ——— d	3	10 33	4 9	4 6
<i>Praecedentium <math>\theta</math> Borealis</i> ——— e	3	17 21	5 41	50 8
<i>Earum Australis clarior.</i> ——— f	3	25 32	6 2	44 6
<i>Quae sequitur <math>\delta</math></i> ——— ——— g	3	35 23	43 27	5
<i>Contiguarum inter nares &amp; }</i> $\theta$				
<i>Palilicium Borea</i> ——— ——— }	3	59 45	5 47	16 4
<i>Earundem Australior</i> ——— $\theta$	4	0 11	5 52	55 4
<i>Duarum supra <math>\theta</math> Borea</i> ——— h	4	2 32	5 23	43 7
<i>Earundem Australior</i> ——— i	4	7 44	5 36	40 8
<i>Suo <math>\theta</math> trium in recta praecedens</i> k	4	19 27	6 9	45 4
<i>Earum media</i> ——— ——— l	4	26 55	6 7	35 2
<i>2<sup>va</sup> <math>\theta</math> sequentium Borea</i> ——— m	4	30 26	5 37	49 7
<i>Oculus Boreus Tauri</i> ——— e	4	30 31	2 35	58 3
<i>Sequentium <math>\theta</math> Australis</i> ——— n	4	32 35	5 41	00 8
<i>Trium sub <math>\theta</math> sequens</i> ——— o	4	45 55	6 0	35 7
<i>Palilicium Bayero</i> $\alpha$	5	50 20	5 29	50 1
<i>Qua hanc sequitur proxime</i> — p	6	17 35	6 3	20 7
<i>Contig. sequentium Australis</i> — q	6	30 34	6 19	19 6
<i>Borea &amp; clarior</i> ——— ——— $\sigma$	6	33 12	6 12	35 7

II. *Solutio Problematis à Dom<sup>no</sup> G. G. Leibnitio, Geometris Anglis nuper propositi. Per Brook Taylor, LL. D. & R. S. Secr.*

CUM Dom. G. G. *Leibnitius* nuper defunctus, in controversiâ jampridem ortâ circa inventionem Methodi Fluxionum, ( quam is Differentiallem vocare maluit, sibi que pertinaciter appropriari nifus est, ) nihil omnino responsi dederit argumentis, quibus inclyti istius Inventi gloria Dom<sup>no</sup> *Newtono* vindicaretur ; en tandem, hortante Dom<sup>no</sup> *Joh. Bernoulli*, Problema Geometris *Anglis* solvendum proposuit ; quo scilicet vires eorum in Methodo istâ experiretur ; quasi Problematis istius Solutioni si cæteri istius Nationis deprehendantur impares, rectè concludatur, nec ipsum *Newtonum*, qui, fatente etiam *Leibnitio*, ab hujusmodi contemplationibus jam jure immunis esse debet, olim fuisse parem inventioni istius Methodi. Sive Problema solvatur, sive insolutum maneat, nihil exinde consequetur quod *Newtonum* afficiat ; nec istis certè *Leibnitii* Favoribus, qui Problematis solutionem etiamnum continenter efflagitant, jus ullum est nos ad certamen ingeniorum tantâ cum licentiâ provocandi ; adeoque Problema eorum jure merito negligi possêt. Verùm ne aliquando exinde occasionem triumphandi arripiant, si hoc Problema maneat ab *Anglis* omninò intactum, ipse, Geometra longè non summi inter nostrates subsellii, inducor, ut solutionem edam qualem qualem Problematis, nec usu, nec difficultate adèò insignis.

Problema à *Leibnitio* primò propositum, ita fuit intellectum quasi nihil aliud requisitum fuisset, quam ut secarentur ad angulos rectos Hyperbolæ Conicæ iisdem Centro & Verticibus descriptæ. Verùm cum illi nuncia-

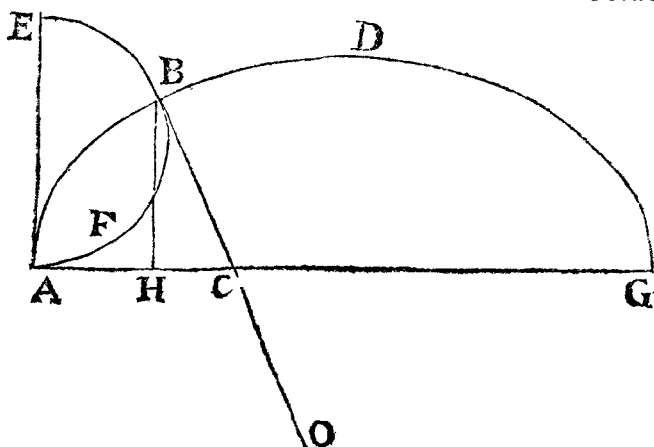
tum fuerat hunc casum à quibusdam *Anglis* fuisse illicò solutum, rescripsit, non solutionem casûs particularis, sed generalem requiri. Quo factum est ut solutiones istæ particulares non editæ fuerint; verùm in *Transactiōe Philosophicâ* N° 347. subinde prodiit Solutio maximè generalis. Sed nec illâ contenti fuerunt *Leibnitius* & *Fautores* ejus, quin illam derisui habuère, quasi qui illam excogitaverat non potuisset eam ad casum specialem applicare. Si nondum viderint quomodo ex illâ æquationes sint deducendæ, id profectò illorum imperitiæ tribuendum erit. Paulò ante *Leibnitii* obitum prodiit tandem Problema sequens; quod quidem diversimodè solvi potest, premendo vestigia Solutionis generalis modò citatæ, sed quod in præsentia solvimus ut sequitur.

### Problema.

*Super rectâ AG tanquam axe, ex puncto A educere infinitas Curvas, qualis est ABD, ejus naturæ, ut radii Osculi, in singulis punctis B & ubique ducti, BO secantur ab axe AG in C, in datâ ratione, ut nempe sit BO ad BC ut 1 ad n.*

*Deinde construenda sunt Trajectoriæ EBF primas Curvas ABD normaliter secantes.*

Solutionis



## Solutionis Pars prima;

*Nempe Inventio Curvarum secundarum ABD.*

1. **D**UCTâ ordinatâ  $BH$  ad axem  $AG$  normali, sint, Abscissâ  $AH=z$ , Ordinata  $HB=x$ , Curva  $AB=v$ . Tum per Methodum Fluxionum directam erit  $BC=\frac{\dot{v}}{\dot{z}}x$ , & fluente uniformiter  $v$ ,  $BO=\frac{\dot{v}x}{\dot{z}}$ . Unde per conditionem Problematis fit  $BO \left( \frac{\dot{v}x}{\dot{z}} \right) : BC \left( \frac{\dot{v}x}{\dot{z}} \right) :: 1 : n$ ; adeoque  $\dot{z}x - n\dot{z}\dot{x} = 0$ .

2. Collatâ hâc æquatione cum formulâ Fluxionum secundâ, in calce *Prop. 6. Methodi Incrementorum*, invenitur  $\dot{z}x^{-n} = \dot{v}a^{-n}$ ; existente  $a$  linea data, per cujus valorem potest Curva  $ABD$  accommodari conditioni alicui Problemati annexæ.

3. Pro  $\dot{v}$  scripto ipsius valore  $\sqrt{\dot{x}^2 + \dot{z}^2}$ , migrat æquatio  $\dot{z}x^{-n} = \dot{v}a^{-n}$  in hanc  $\dot{z} = \frac{\dot{x}x^n}{\sqrt{a^{2n} - x^{2n}}}$ . Unde datur  $z$  ex datâ  $x$ , per quadraturam Curvæ cujus abscissâ existente  $x$  est ordinata  $\frac{x^n}{\sqrt{a^{2n} - x^{2n}}}$ .

4. Sint  $\sigma$  &  $\tau$  numeri integri, vel affirmativi vel negativi, tales ut sit Curvarum isto modo provenientium simplicissima, ea cujus est Abscissa  $y$ , & Ordinata  $y^{\frac{1-n+2\sigma n}{2n}} \times a^{-y} |^{\tau - \frac{1}{2}}$ ; tum erit ea omnium Curvarum simplicissima, per quarum Quadraturam datur Abscissâ  $x$  ex datâ Ordinatâ  $x$ .

5. Est Curva  $ABD$  Geometrica, quoties pro  $n$  sumitur reciprocum numeri cujusvis imparis.



6. In prædictis Curvam  $ABD$  consideravimus ut versùs axem  $AG$  concavam, quo in casu maxima ordinata  $x$  æqualis est lineæ datæ  $\alpha$ , quam Parametrum Curvæ commode vocare licet. Et in hoc casu Curva actu occurret Axi. Unde fluente ipsius  $\frac{x x^n}{\sqrt{\alpha^{2n} - x^{2n}}}$  debitè sum-

ptâ, hoc est, ita ut simul evanescant  $z$  &  $x$ , transibit Curva per punctum datum  $A$ , sicut postulat Problema.

7. Sed si quærat<sup>r</sup> Curva  $ABD$ , quæ sit versùs axem convexa, ad eundem modum pervenietur ad æquationem  $z = \frac{\alpha^n x}{\sqrt{x^{2n} - \alpha^{2n}}}$ ; quæ etiam ex æquatione priori de-

rivari potest mutando signum ipsius  $n$ . Et in hoc casu est curva  $ABD$  Geometrica, quoties pro  $n$  sumitur reciprocum cujusvis numeri paris. In hoc verò casu Ordinata omnium minima  $x$  æqualis est Parametro  $\alpha$ ; adeoque Curva nusquam occurrit Axi. Quare limitatur Problema ad casum priorem.

8. Ex præmissis facilè colligitur Curvas omnes  $ABD$  esse inter se similes, & circa punctum datum  $A$  similiter positas, lateribus earum homologis existentibus proportionalibus Parametris  $\alpha$ .

### Solutionis Pars altera;

#### *Nempe Inventio Curvæ secantis*

9. Ex § 2. fit  $\dot{v} : \dot{z} :: \alpha^n : x^n$ . Sed est  $BC : BH :: \dot{v} : \dot{z}$ , Unde fit  $BC : BH :: \alpha^n : x^n$ . Ex conditione verò Problematis est  $BC$  tangens Curvæ quæsitæ  $EBF$ . Quare si jam sumantur  $AH (z)$  &  $BH (x)$  pro coordinatis Curvæ  $EBF$ , Curvâ ipsâ  $EB$  existente  $r$ , erit, per Meth. Flux. direct.  $r : -\dot{x} :: (BC : BH ::) \alpha^n : x^n$ . Unde fit  $\frac{x^n}{\alpha^n} = \frac{-\dot{x}}{r}$ .

10. In Curva  $ABD$  finge æquationem  $z = \frac{x \dot{x}^n}{\sqrt{a^{2n} - x^{2n}}}$  transformari in æquationem signis radicalibus non affectam  $z = A \dot{x} \frac{x^n}{a^n} + B \dot{x} \frac{x^{3n}}{a^{3n}} + \text{etc.}$  Tum regrediendo

ad Fluentes fiet  $z = \frac{1}{n+1} A \frac{x^{n+1}}{a^n} + \frac{1}{3n+1} B \frac{x^{3n+1}}{a^{3n}} + \text{etc.}$

coefficiente novâ introductâ nullâ, quoniam per conditionem Problematis debent simul nasci  $z$  &  $x$ . Hinc vice  $\frac{x^n}{a^n}$  substituto ipsius valore  $\frac{-x}{r}$  in § 9 invento, fit

$z = \frac{1}{n+1} A x \frac{-\dot{x}}{r} + \frac{1}{3n+1} B x \frac{-\dot{x}^3}{r^3} + \text{etc.}$  quæ æquatio

fluxionalis est primi gradûs ad Curvam quæsitam  $EBF$ . Revocatur autem ad formulam simpliciore in terminis numero finitis, modo sequenti.

11. Fluat uniformiter  $r$ , & existente  $a$  quantitate non fluente, fit  $\frac{-x}{r} = \frac{s^n}{a^n}$ . Substituto hoc valore ipsius  $\frac{-x}{r}$  in æquatione novissimè inventâ, atque ductâ æquatione in  $\frac{s}{x}$ , transformatur ea in hanc  $\frac{z s}{x} = \frac{1}{n+1} A \frac{s^{n+1}}{a^n} + \frac{1}{3n+1} \times B \frac{s^{3n+1}}{a^{3n}} + \text{etc.}$  Unde capiendo Fluxiones fit  $\frac{s \dot{z} x + s \dot{x} z - s \dot{x} x}{x^2}$

$= A s \frac{s^n}{a^n} + B s \frac{s^{3n}}{a^{3n}} = \frac{\dot{s} s^n}{\sqrt{a^{2n} - s^{2n}}}$ . Quod ultimum constat ex

Analogia Serierum  $A \dot{x} \frac{x^n}{a^n} + \text{etc.}$  &  $A s \frac{s^n}{a^n} + \text{etc.}$  Hinc

pro  $s$  &  $\dot{s}$  substitutis eorum valoribus ex æquatione  $\frac{-x}{r} = \frac{s^n}{a^n}$  collectis, elicitur æquatio  $n x^2 z \dot{z} - x \dot{x} z \dot{z} -$

$n \dot{x} x \dot{z}^2 - \ddot{x} \dot{x} x^2 = 0$ . Quæ ad Fluxiones primas revocatur modo sequenti.

fit

12. In termino ultimo  $-xx^x$  vice  $\ddot{x}x$  scripto ipsius valore  $-zz$ , & æquatione deinde applicata ad  $z$ , fit  $ax^2z - \ddot{x}xz - nxxz + x\ddot{x}z = 0$ . Quæ æquatio in  $x^{n-1}$  ducta est Fluxio æquationis  $-xx^{n-1}z + x^{1-n}z = a^{1-n}r$ ; existentibus  $a$  &  $r$  non fluentibus. Est ergo  $-xx^{n-1}z + x^{1-n}z = a^{1-n}r$ , seu  $zx - zx \times a^{n-1} = \dot{x}x^n$ , æquatio fluxionalis primi gradûs ad Curvam quæsitam  $EBF$ .

13. In istâ autem æquatione est  $a$  valor Ordinatæ  $BH$ , quando incidit punctum  $H$  in punctum  $A$ .

14. Haud proclive est æquationem  $zx - zx \times a^{n-1} = rx^n$ , manente  $n$  in terminis generalibus, revocare ad æquationem Fluentes tantum involventem, vel ad quadraturam Curvarum. Sed puncta curvæ  $EBF$  possunt commodè inveniri per descriptionem Curvæ  $ABD$ , & Curvæ cujusdam Geometricæ. Per Geometricam hic intelligo Curvam, cujus æquationem non ingrediuntur Fluxiones, nec fluentes in Indicibus dignitatum. Secetur enim Curva  $ABD$ , cujus Parameter sit  $a$ , in  $B$ , à Curvâ geometricâ cujus æquatio est  $a\alpha^n x^n - za^n x^n = xa^n \sqrt{a^{2n} - x^{2n}}$ ; atque erit punctum illud intersectionis  $B$  ad unam ex Trajectoriis quæsitis, nempe quæ transit per punctum  $E$ , existente  $AE = a$  & normali ipsi  $AG$ .

15. Hinc si  $ABD$  sit Curva Geometrica, erit etiam  $EBF$  geometrica.

*Scholium.* Potest & alio modo inveniri æquatio  $zx - zx \times a^{n-1} = rx^n$ . Nam certâ quâdam Analyâ quam nunc celare statuo, inveni æquationem  $\frac{a}{x} = \frac{r}{r + x}$ . Quâ comparatâ cum æquatione  $\frac{x^n}{a^n} = \frac{-x}{r}$  ( § 9 ) eliminando  $a$  &  $a$ , tandem pervenitur ad prædictam æquationem  $zx - zx \times a^{n-1} = rx^n$ .

*Exemplum.*

*Exemplum.* Ad demonstrationem Solutionis nostræ suffecerit exemplum simplicissimum. Sit itaque  $n=1$ ; quo in Casu est  $ABD$  semicirculus diametro  $AG$  descriptus, atque est  $EBF$  item semicirculus descriptus diametro  $AE$ . Est autem in hoc Casu  $\frac{\dot{x}x^n}{\sqrt{a^{2n}-x^{2n}}} = \frac{\dot{x}x}{\sqrt{a^2-x^2}}$ . Unde

in § 3. fit  $\dot{z} = \frac{\dot{x}x}{\sqrt{a^2-x^2}}$ ; adeoque  $z = a - \sqrt{a^2-x^2}$ , quæ æquatio est ad Circulum diametro  $AG=a$  descriptum, ut fieri debuit. Item pro  $n$  scripto 1, æquatio  $zx - zx \times a^{n-1} = \dot{r}x^n$  (§ 12.) migrat in hanc  $\dot{z}x - z\dot{x} = \dot{r}x$ . Unde exterminando  $r$  ope æquationis  $\dot{r}r = \dot{x}x + \dot{z}z$ , fit  $\frac{2\dot{z}zx - x\dot{z}^2}{x^2} = -\dot{x}$ ; adeoque regrediendo ad Fluentes  $\frac{\dot{z}z}{x} = -x + a$ , quæ æquatio est ad Circulum diametro  $AE=a$  descriptum, ut etiam fieri debuit.

III. *Extract of a Letter of Dr. Chr. Hunter, M.D. to Dr. J. Woodward, R. S. S. from Durham, giving an Account of a Roman Inscription, lately dug up in the North of England; with some Historical and Chronological Remarks thereon.*

**T**HE Inscription which comes herewith, (*Fig. II.*) was dug up, two Years ago, in the *Roman CASTRUM*, near *Lanchester*: The Inscription is very legible, and gives me reason to hope, a Search after the first Fortifying this Place will not be unnecessary; especially, being able to fix the Time of *Gordian's* Repair-

Repairing this Fortrefs, to the 243d Year of Christ. We may reasonably ascribe the Foundation to the prudent Administration of *Julius Agricola*, in the Reign of *Fl. Vespasian*, about 169 Years before. In Confirmation of this, I find the following Particulars very material, and think it not unbecoming to begin my Enquiry with *Vespasian's* first Appearance upon the Theatre of Fame in *Britain*.

In the Second Year of the Emperor *CLAUDIUS*, *Ann. Dom.* 44. the *Romans* invaded *Britain*, under the Command of *Aulus Plautius*, in which Expedition *Vespasian* \*, then Legate of the Second Legion, made a glorious Figure; having been engaged in no less than thirty Battels, and reduced two powerful Provinces, above twenty Towns, and the Isle of *Wight*. All these Successes, tho' continued with good Improvements in some of the following Years and Governments, could not frighten the Natives into an entire Submission; especially, no Advance being made into the Country of the *Brigantes*, till the Advancement of *Vespasian* to the Imperial Throne, about 26 Years after, *Ann. Dom.* 70. Then the whole Empire was deliver'd from the Miseries of *Nero's*, and the short but lamentable Devastations of the three succeeding Reigns: *Vespasian* then resolv'd to push on his begun Conquests in *Britain*; choice Armies, commanded by experienced Generals, are sent over; and the XX<sup>th</sup> Legion, having in the preceding Troubles acted seditiously, (not without Difficulty) was reduced to submit to *Vespasian* (most of the Officers as well as Soldiers having been advanced by *Vitellius*). *Julius Agricola* is constituted Legate, who, under the Governour *Petilius Cerealis*, bore a considerable Share

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\* *Suetonius*, *Vespasian*, Cap. 4.

in the Successes against the *Brigantes*; \* “ Sed primò  
 “ *Cerealis* modò labores & discrimina, mox & gloriam  
 “ communicabat: Sæpe parti Exercitus in experimen-  
 “ tum, aliquando majoribus copiis ex eventu præfecit.  
*Tacitus* afterwards in a few Words sums up the Whole  
 of *Cerealis* his Acquisitions, † “ Terrorem statim intu-  
 “ lit *Petilius Cerealis*, *Brigantum* Civitatem, quæ nu-  
 “ merosissima Provinciæ totius perhibetur, aggressus;  
 “ multa prælia, & aliquando non incruenta; magnam-  
 “ que *Brigantum* partem aut victoria amplexus, aut  
 “ bello. . . . Notwithstanding these Advantages, I dare not  
 suppose the *Romans* to have then penetrated so far into  
 this Province as our *Longovicum*, which is situate so  
 near the Northern Bounds of the *Brigantes*, that at pre-  
 sent it's not distant above twelve Miles from *Corbridge*,  
 the Roman *Curia*, the chief Town of the adjoining Peo-  
 ple the *Otadini*. I now advance to my principal Mo-  
 tive, ( I hope its Length may deserve Pardon, being un-  
 der no Obligation to account for the Government of  
*Jul. Frontinus* Successor to *Cerealis* ) to fix upon the se-  
 cond Year of *Julius Agricola*'s Government for this Work,  
 which *Tacitus* thus describes, ‡ “ Sed ubi *Ællas* adve-  
 “ nit contracto Exercitu— loca Castris ipse capere,  
 “ æstuaria ac sylvas ipse prætentare: & nihil interim  
 “ apud Hostes quietum pati, quo minus subitis Excur-  
 “ sibus popularetur; atque ubi satis terruerat, parcen-  
 “ do rurius irritamenta Pacis ostentare. Quibus rebus  
 “ multæ Civitates quæ in illum diem ex æquo egerant,  
 “ datis Obsidibus iram posuere, & Præfidiis Calte inf-  
 “ que circumdatæ, tantâ ratione curæque, ut nulla an-  
 “ tè *Britanniæ* nova pars illacessita transierit. This ex-  
 cellent Conduct *Tacitus* further confirms from the Ob-

\* *Tacit. Vit. Agric. 8.*† *Cap. 17.*‡ *Cap. 20.*

servation of Others. “ Adnotabant periti, non alium  
 “ Ducem Opportunitates locorum sapientius legisse,  
 “ nullum ab *Agricola* positum Castellum aut vi Ho-  
 “ stium expugnatum, aut pactione aut fugâ delertum.

*Agricola*, this Summer, having quieted so large a  
 Tract, and finished so many Fortresses, it cannot be ex-  
 pected all should be built with the most exquisite Art,  
 sufficient to perpetuate them. I proceed to *Gordian's*  
 Repairs ; whose Historian *Julius Capitolinus* having ne-  
 ver once named *Britain*, yet giving so many Hints of  
 the excellent Oeconomy of his Government, under the  
 prudent Administration of his Father-in-Law *Misitheus*,  
 I dare not fix this Work till the Third Year of his Reign,  
 He having before been under the Direction of the Eu-  
 nuchs and Officers of the Court, whom *Capitolinus*  
 represents, in *Misitheus* his Letter to *Gordian*, to have  
 prostituted all Employments to their own Covertness  
 and mercenary Creatures.

*Durham*, July 5.

1717.

IV. *A new Genus of PLANTS, call'd Araliastrum, of which the famous Nin-zin or Gin-seng of the Chineses, is a Species. Communicated by Mr. Vaillant Prædemonstrator at the Royal Garden at Paris, to the Learned Dr. Will. Sherrard, LL. D. late Consul at Smyrna, and by him to the Royal Society.*

**A** *Raliastrum* is a Genus of Plants, whose Flower A\* is complete †, regular, polypetalous, and hermaphrodite, standing on the Ovary B. The Ovary, which is crown'd by a Calyx cut into several Parts, becomes a Berry D, in which are, for the most part, two flat Seeds, like a Semicircle, which both together represent a sort of a Heart. Add to this the Stalk, which is single, ending in an Umbel of which each Ray bears but one Flower. Above the Middle of the Stalk come out several Pedicles, ( as on that of the *Anemone* ) on the Extremities of which grow several Leaves like Rays, or like an open Hand.

*The Species of this Genus are,*

1. *Araliastrum Quinquefolii folio, majus, Nin-zin vocatum* D. Sarrazin. *Gin-seng. Des lettres edifiantes & curieuses, Tom. X. pag. 172.*
2. *Araliastrum Quinquefolii folio, minus.* D. Sarrazin. *Plantula Marilandica, foliis in summo caule ternis, quorum unumquodque quinquefariam dividitur, circa margines serratis. N° 36. Raii Hist. III. 658.*

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\* *vid. ARALIA Inst. rei herb. Tab. 154.*

† Complete, that is to say, that has a Calyx.



3. *Araliastrum Fragrarie folio, minus*. D. Vaillant *Nasturtium Marianum Anemones sylvaticæ foliis, enneaphyllum, floribus exiguis*. Pluk. Mantiss. 135. Tab. 435. Fig. 7.

To shew wherein *Araliastrum* differs from *Aralia*, ( from whence it takes its Name ) 'tis convenient to give also the Character of this last Genus, such as Mr. *Vaillant* establish'd it, in his Demonstrations of the Year 1717.

*Aralia* \* is altogether like the *Araliastrum*, as to the Structure and Situation of its Flower ; but its Berry consists of Five Seeds plac'd round an *Axis*. Moreover, its Leaves are branched, almost like those of *Angelica* ; and its Stalks ( which in some Species are naked, and in others have Leaves set alternately ) bear each several Umbels at their top, in the Form of a Bunch of Grapes.

*The Species of Aralia, are*

1. *Aralia caule aphylo, radice repente*. D. Sarrazin. *Christophoriana Virginiana Zarza radicibus surculosis & fungosis, Sarsaparilla nostratibus dicta*. Pluk. Almag. 98. Tab. 238. Fig. 5. *Zarsaparilla Virginianensis nostratibus dicta, lobatis umbellifera foliis, Americana*. Ejusd. Almag. 396.
2. *Aralia caule folioso levi*, D. Sarazzin. *Aralia Canadensis*. Inst. rei Herb. 300.
3. *Aralia caule folioso & hispido* D. Sarazzin.
4. *Aralia arborescens spinosa*, D. Vaillant. *Angelica arborescens, spinosa, seu Arbor Indica, Fraxini folio, cortice spinoso* Rati Hist. II. 1798. *Christophoriana arbor aculeata Virginianensis* Pluk. Almag. 98. Tab. 20.

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\* vid. Inst. rei Herb. 300. Tab. 154.

All the *Species* of these two *Genera*, except the last of each of them, are common in *Canada*, whence Mr. *Sarrazin*, Counsellor in the upper Council, Physician to his Majesty, and Correspondent of the Royal Academy of Sciences. sent them to the Royal Garden first in 1700.

The Inhabitants of that Colony, and those of *Virginia*, call the first *Species* of *Aralia* by the Name of *Sarsaparilla*, because its Roots have almost the same Figure and Vertues

Mr. *Sarrazin* writes, that he had a Patient who had been cured of an *anasarca*, about two Years before, by the use of a Drink made of these Roots. That able Physician assures us also, that the Roots of the second *Species*, well boyl'd and apply'd by way of *Cataplasme*, are very excellent for the curing of old Ulcers; as also the Decoction of them, with which they bath and syringe the Wounds. He does not at all doubt, but the Virtues of the third *Species* (which I shall briefly describe) are the same with those of the second.

Its Roots creep, and send forth Stalks, which rise commonly to the Height of a Foot and half, and sometimes to two Foot; the bottom part of them is rough, with reddish, stiff and prickling Hairs. These Stalks are set from the Bottom to almost the Top (which are divided successively into several naked Branches charg'd with Umbels) with branch'd alternate Leaves, almost like those of *Podagraria hirsuta Angelica folio* & odore D. Vaillant; which Plant is grav'd in the second Tome of *Boccone's Musaeum*, by the Name of *Cerrefolium rufo Angelica folio, Aromaticum*. Tab. 19. and in *Rivini* by that of *Myrrhis folio Podagrariae*

See the Account of the Chinese *Gin-seng*, in *Phil. Transact. Anni 1713. p. 237.*

V. *Extract of a Letter of Mr. Edw Berkeley from Naples, giving several curious Observations and Remarks on the Eruptions of Fire and Smoak from Mount VESUVIO. Communicated by Dr. John Arbuthnot, M D. and R. S. S.*

**A** *Pril 17. 1717.* with much Difficulty I reach'd the top of Mount *Vesuvius* in which I saw a vast Aperture full of smoak, which hinder'd the seeing its Depth and Figure. I heard within that horrid Gult certain odd Sounds, which seem'd to proceed from the Belly of the Mountain; a sort of Murmuring, Sighing, Throbbing, Churning, Dashing (as it were) of Waves, and between whiles a Noise like that of Thunder or Cannon, which was constantly attended with a Clattering, like that of Tiles falling from the Tops of Houses on the Streets. Sometimes, as the Wind changed, the Smoak grew thinner, discovering a very ruddy flame, and the Jaws of the Pan or Crater, streak'd with Red, and several Shades of Yellow. After an Hour's stay, the Smoak, being moved by the Wind, gave us short and partial Prospects of the great Hollow, in the flat Bottom of which I could discern two Furnaces almost contiguous; that on the Left, seeming about three Yards in Diameter, glow'd with red Flame, and threw up red-hot Stones with a hideous Noise, which, as they fell back, caus'd the fore mentioned Clattering. *May 8.* in the Morning, I ascended to the Top of *Vesuvius* a second time, and found a different face of things. The Smoak ascending upright, gave

gave a full Prospect of the *Crater*, which, as I could judge, is about a Mile in Circumference, and an Hundred Yards deep. A conical Mount had been formed since my last Visit, in the middle of the Bottom. This Mount I could see was made of the Stones thrown up and fallen back again into the *Crater*. In this new Hill remained the two Mouths or Furnaces already mention'd; that on our Left Hand was in the *Vertex* of the Hill which it had formed round it, and raged more violently than before, throwing up every three or four Minutes, with a dreadful Bellowing, a vast Number of red-hot Stones, sometimes in appearance above a thousand, and at least 300 Foot higher than my Head as I stood upon the Brink. But there being little or no Wind, they fell back perpendicularly into the *Crater*, increasing the conical Hill. The other Mouth to the Right was lower in the side of the same new formed Hill. I cou'd discern it to be fill'd with red-hot liquid Matter, like that in the Furnace of a Glass-House, which raged and wrought as the Waves of the Sea, causing a short abrupt Noise like what may be imagin'd to proceed from a Sea of Quicksilver dashing among uneven Rocks. This Stuff wou'd sometimes spew over and run down the convex side of the conical Hill, and appearing at first red-hot, it changed Colour, and harden'd as it cool'd, shewing the first Rudiments of an Eruption, or if I may so say, an Eruption in Miniature. Had the Wind driven in our Faces, we had been in no small Danger of stifling by the sulphurous Smoak, or being knock'd on the Head by Lumps of molten Minerals, which we saw had sometimes fallen on the Brink of the *Crater*, upon noise shots from the Gulf at Bottom. But as the Wind was favourable, I had an opportunity to survey this odd Scene for above an Hour and a half together;

together; during which it was very observable, that all the Volleys of Smoak, Flame, and burning Stones, came only out of the Hole to our left, while the liquid Stuff in the other Mouth wrought and overflow'd as hath been already described.

June 5. After a horrid Noise, the Mountain was seen at *Naples* to spew a little out of the *Crater*. The same continu'd the 6th. The 7th, nothing was observ'd til within two Hours of Night, when it began a hideous bellying, which continued all that Night and the next Day til Noon, causing the Windows, and as some affirm, the very Houses in *Naples* to shake. From that time it spew'd vast Quantities of molten Stuff to the South, which stream'd down the side of the Mountain, like a great Pot boyling over. This Evening I return'd from a Voyage thro' *Apulia*, and was surpris'd, passing by the North side of the Mountain, to see a great Quantity of ruddy Smoak lie along a huge Tract of Sky over the River of molten Stuff which was it self out of sight. The 9th, *Vesuvius* rag'd less violently: that Night we saw from *Naples* a Column of Fire shoot between whiles out of its Summit. The 10th, when we thought all wou'd have been over, the Mountain grew very outrageous again, roaring and groaning most dreadfully. You cannot form a juster dea of this Noise in the most violent Fits of it, than by imaginng a mix'd Sound made up of the raging of a Tempest, the Murmur of a troubled Sea, and the Roaring of Thunder and Artillery, confus'd all together. It was very terrible as we heard it in the further End of *Naples*, at the Distance of above twelve Miles. This mov'd my Curiosity to approach the Mountain. Three or four of us got into a Boat, and were set ashoar at *Torre del Greco*, a Town situate at the Foot of *Vesuvius* to the South-

South-West, whence we rode four or five Miles before we came to the burning River, which was about Mid-Night. The Roaring of the *Volcano* grew exceeding loud and horrible as we approach'd. I observed a Mixture of Colours in the Cloud over the *Crater*, green, yellow, red and blue; there was likewise a ruddy dismal Light in the Air over that Tract of Land where the burning River flow'd; Ashes continually shower'd on us all the way from the Sea-Coast. All which Circumstances, set off and augmented by the Horror and Silence of the Night, made a Scene the most uncommon and astonishing I ever saw; which grew still more extraordinary as we came nearer the Stream. Imagine a vast Torrent of liquid Fire rolling from the Top down the Side of the Mountain, and with irresistible Fury bearing down and consuming Vines, Olives, Fig-trees, Houses, in a word, every thing that stood in its way. This mighty Flood divided into different Channels, according to the Inequalities of the Mountain. The largest Stream seem'd half a Mile broad at least, and five Miles long. The Nature and Consistence of these burning Torrents hath been described, with so much Exactness and Truth, by *Borellus*, in his Latin Treatise of *Mount Ætna*, that I need say nothing of it. I walked so far before my Companions, up the Mountain along the side of the River of Fire, that I was oblig'd to retire in great haste, the sulphureous Steam having surpriz'd me, and almost taken away my Breath. During our Return, which was about Three-a-Clock in the Morning, we constantly heard the Murmur and Groaning of the Mountain, which between whiles would burst out into louder Peals, throwing up huge Spouts of Fire and burning Stones, which falling down again resembled the Stars in our Rockets. Sometimes I ob-

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serv'd two, at others three distinct Columns of Flame, and sometimes one vast one that seem'd to fill the whole *Crater*. These burning Columns, and the fiery Stones seem'd to be shot a 1000 Foot perpendicular above the Summit of the *Volcano*. The 11th at Night, I observ'd it, from a Terrass in *Naples*, to throw up incessantly a vast Body of Fire and great Stones to a surprising Height. The 12th in the Morning, it darken'd the Sun with Ashes and Smoak, causing a sort of Eclipse. Horrid Bellowings this and the foregoing Day were heard at *Naples*, whither part of the Ashes also reached. At Night I observed it throw up Flame, as on the 11th. On the 13th, the Wind changing, we saw a Pillar of black Smoak shot upright to a prodigious Height. At Night I observed the Mount cast up Fire as before, tho' not so distinctly because of the Smoak. The 14th, A thick black Cloud hid the Mountain from *Naples*. The 15th, in the Morning, the Court and Walls of our House in *Naples* were cover'd with Ashes. In the Evening, Flame appear'd on the Mountain thro' the Cloud. The 16th, the Smoak was driven by a Westerly Wind from the Town to the opposite side of the Mountain. The 17th, the Smoak appear'd much diminish'd, fat and greasy. The 18th, the whole Appearance ended, the Mountain remaining perfectly quiet without any visible Smoak or Flame. A Gentleman of my Acquaintance, whose Window look'd toward *Vesuvius*, assur'd me, that he observ'd this Night several Flashes, as it were of Lightening, issue out of the Mouth of the *Volcano*. It is not worth while to trouble you with the Conjectures I have formed concerning the Cause of these Phænomena, from what I observed in the *Lacus Amsancti*, the *Solfatara*, &c as well as in Mount *Vesuvius*. One thing I may venture to say, that I saw the fluid Matter rise out of the Centre  
of

of the Bottom of the *Crater*, out of the very middle of the Mountain, contrary to what *Borellus* imagines, whose Method of explaining the Eruption of a *Volcano* by an inflexed Syphon, and the Rules of *Hydrostaticks*, is likewise inconsistent with the Torrent's flowing down from the very *Vertex* of the Mountain. I have not seen the *Crater* since the Eruption, but design to visit it again before I leave *Naples*. I doubt there is nothing in this worth shewing the Society; as to that, you will use your Discretion.

*E. Berkeley.*

VI. *An Account of an extraordinary TUMOUR or WEN lately cut off the Cheek of a Person in Scotland. Communicated to the Royal Society by Dr. Thomas Bower, M. D. and F. R. S.*

**I**T is generally acknowledg'd, that the exact Observation of internal Diseases, and the faithful Accounts of external Tumours, and extraordinary Cases in Chirurgery, have contributed very much to the Advancement of Medicine. *Hippocrates* and *Galen*, and other ancient Fathers of Medicine, have set us fair Copies of this; and the Moderns, happily following their Footsteps, have illustrated this Matter by many curious Observations and Reflections. The Royal Societies and Colleges of *Virtuosi*, that are now over all *Europe*, have taken much pains in this Affair, and have given us many Instances and Examples of Extraordinary Cases in Medicine, which are of great use to all the Practisers of Physick and Chirurgery. According to these laudable Examples I shall, for the Satisfaction



of the Curious and Ingenious, give a true and faithful Account of an extraordinary Excrecence cut off from the Cheek of a Man, which weighed Nineteen Pounds, and the Patient entirely recover'd in few Weeks time. I never before saw the like, nor never read of it in any Author, tho' I have consulted many on the Head. This Excrecence is preserved among the Rarities of the College of Physicians at *Edinburgh*. The Physician concern'd in this Affair, was Dr. *Alexander Russel* of *Elgine*, a learned and ingenious Man, and the Operator was the ingenious Mr. *George Gordon* of *Keith*, from whom I had the following Information.

*Alexander Palmer*, of the Parish of *Keith*, in the County of *Bamff*, in the North of *Scotland*, now about Fifty Four Years of Age, observed, when about Twenty Seven, a little hard Swelling in the Muscle of the lower Jaw on the Left Side, without any Hurt or manifest Occasion, which at first went on slowly, but afterwards it proceeded more quickly, and the older it grew, it still came on the faster; until it increased to a prodigious Bulk and Weight: From the first Appearance of this Tumour to the total Excision of it, there were about Twenty Seven Years. He had excessive Pains and Uneasiness in it, and at last it mightily extenuated and emaciated him, who was otherwise a strong and robust Man.

This Excrecence was of the natural Colour of the Skin, and seem'd to be an *Atheroma*, being a glandulous Substance with several big Blood-Vessels in it, and had Hair growing on it, as on the other Parts of the Body, as may yet be seen. It was almost round and very hard, and was as sensible as any other Part of the Body; for, when the poor Man was working in the  
Fields,

Fields, some six or seven Years ago, he accidentally made a great Gash or Wound in it with a sharp Iron, which was very painful, but was cured by a Surgeon, after the manner of an ordinary Wound; the Cicatrice is still to be seen in it.

This Excrecence having grown so big, was attach'd to the Muscle under the Left Eye, call'd *Obliquus minor* or *inferior*, to the Ear and its Muscles, and to the Muscle of the lower Jaw, named *Deprimens*. By reason of its great Bulk and Weight, it could not hang down freely without some Support, therefore it rested on the top of the Shoulder, which made a considerable Dimple in it, that is yet very observable; besides, it was holden up by the Man's Hand in the Day-time, and laid on a Pillow in the Night-season.

Some three or four Days before the total Excision was made, the Patient observed this Tumour begin to mortify at the lower end, which made him so uneasy, that he took a Knife and cut off a good part of it. This occasion'd a great Hæmorrhage; so that he reckon'd there was lost a *Scots* Pint or four Pounds of Blood, before it could be stop't. The Patient, after so great Trouble and Pain, at last applied himself to Mr *Gordon*, Surgeon of the Place, who made a total Extirpation of it, on the 19th of *January*, 1717.

He made a close Ligature, taking in the Basis of the Excrecence, and all the loose Skin, and contracting it as much as possible, he cut it entirely off with a sharp Rasour. There gush'd out of the Excrecence, after it was cut off, and was lying on the Ground, as near as could be guess'd, two Pounds of Blood; for it was nourish'd by several large Blood-Vessels, perhaps by some Branches of the Carotide Artery much enlarged, and other Blood-Vessels coming  
from

from the Ear, and the Muscles of the Eye and lower Jaw abovementioned. When Mr. Gordon brought it to us, which was full three Months after it was cut off, we cut off with a Knife about a quarter of an Inch broad of the Basis of it; and in that small space we observed four big Blood-Vessels. The basis, as it now appears, is five Inches Diameter, which seems too large for the whole side of the Face: So that after the Excision, I think the loose Skin has turn'd backwards, which may make the Basis now appear so big.

After all this Blood was lost, the Excrecence was weighed, and was full Nineteen Pound Weight; so that before his own Incision and this Operation, it behoved to be several Pounds heavier, which is a most prodigious Weight to be depending on such a place. This Tumour was of a Spheroidical Figure, and when measured, was Thirty four Inches about by the longest way, and Twenty eight by the broadest.

The Hæmorrhage, which was great, was stopped by the Vitriolic Powders and other Astringents, and the ordinary Dressing was used. So this great Cure was completed in six Weeks time, and the Patient entirely recover'd, and goes about his Business, to the great Admiration and Astonishment of every body. The Lid of his Left Eye continues still downwards a little, as does that same side of the Mouth, which was occasion'd by the great Weight depending on that side of the Face; but it may be expected they may come again to their right Posture; for the Head, at first after cutting, enclined much to the Right side, by reason of the great Weight on the Left Cheek having been removed; but it now begins to stand upright, since he is perfectly recovered. Tho' the Skin, and even a deal of the musculous part of the Cheek and  
lower

lower Jaw was cut away, yet, according to the Information I have from Mr. *Gordon* the Operator, it is grown up again, and is of the ordinary Colour of the Skin, and like the other side of the Face; so that there grows Hair on that side of the Face as well as on the other, which he ordinarily shaves; and this is as surprizing as any thing in the whole Affair.

I have given a true and plain Account of this extraordinary Case from certain Information; I have contented my self to relate only Matters of Fact, without making any Observations or Reflections on it; for I leave it to the Philosophers and *Virtuosi* to make their own Reasonings and Refinements as seems best to themselves.

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VII. *An Account of an Experiment to prove an interspers'd Vacuum; or to shew that all Places are not equally full.*

**T**HIS Experiment was made before the KING, and HER Royal Highness the Princess of Wales, at Hampton-Court, in the Month of September 1717. afterwards before the ROYAL-SOCIETY, on Thursday, December 5. 1717. and since that, in Channel-Rowe, Westminster, before some Members of the Royal-Society, by J. T. Desaguliers, M. A. F. R. S. as follows.

Having had the Honour to make some Experiments last Year before his Majesty and their Royal Highnesses the Prince and Princess of Wales; among others, I shew'd that of a Guinea and a Piece of fine Paper; then of a Guinea and a Feather dropt together from the top of an exhausted Glass Receiver about 20 Inches high: both  
which

which fell to the Bottom at the same Instant of Time: Now since the chief *Resistance* of a *Medium* ( and indeed almost all of it ) depends upon the † Quantity of its Matter ; therefore this Diminution of Resistance, whereby the Feather fell as soon as the Guinea, shew'd a Diminution of the Quantity of Matter, and consequently prov'd an *interspers'd Vacuum*. Some time after this, I was inform'd that some *Plenists* here in *England* objected against the Shortness of the Glass-Receiver ; as if the Difference of Time in the Fall of the two Bodies, which they affirm'd to be real, could not be perceiv'd in such a Glass ; and that some Philosophers from abroad affirm'd that in a Glass-Receiver 7 or 8 Foot long, there would be such a manifest Difference in the Time of the Fall of the said Bodies, as to shew this Experiment no Proof of a *Vacuum* ; though at the same time, some of the Objectors well knew that there could be no Receivers of half that Length made at the Glass House, and therefore thought the Experiment impracticable. To obviate this, I contriv'd a Machine for the purpose, which consisted of a strong wooden Frame 15 Foot high, that held the Air-Pump and four Cylindric Glass-Receivers of about two Foot long each, and six Inches Diameter : Of these, having set the first upon the Air-Pump Plate, I laid on the Top of it a Brass-Plate of seven Inches Diameter, that had an oil'd Leather fix'd to it above and below, with an Hole through the middle, of between four and five Inches Diameter ; then on that Plate I set the next Receiver, with a like Plate at top ; and after the same manner fix'd the other two with Plates between them : The upper Receiver being a little narrower at the Neck,

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† See Sir *Is. Newton's Principia*, Book II. Prop. 43.

went into the Hole of a Board. whereby it was screw'd down pretty hard on the other Glasses, and fix'd to the whole Machine. On the top of this upper Receiver I laid the Brass Plate, wet Leather, and Brass Springs which contain'd the Bodies to be dropt

Having acquainted His Majesty with what I had prepar'd, he order'd me to shew him the Experiment with this long compounded Receiver, at *Hampton-Court*; and when I made it before him and her Royal Highness, he was pleas'd ( by pulling down a String fix'd to a Leaver at the top of the Machine ) to let loose the Bodies himself, to see that the Experiment was fair.

When the Receiver was full of common Air before Pumping, the Guinea came to the Bottom, just as the Paper was about the Middle of the second Glas; but when the Receiver was exhausted, the Guinea and Paper came to the Bottom precisely in the same Instant of Time.

Upon my giving an account of the Success of this Experiment to the *Royal Society*, they order'd me to repeat it before them on the 5th Day of *December* 1717, being the *Thursday* next after the Yearly Meeting for choosing Officers on *St. Andrew's Day*; on which Day an annual Experiment is appointed to be made, in Conformity to the Will of their late worthy Member and Benefactor *Sir Godfrey Copley*.

I made the Experiment first with two of the Receivers; then with all the four; dropping a Guinea and a small Piece of Paper together; and the Success answer'd Expectation: But not being willing to try with a Down-Feather, because I fear'd the Air might insinuate between some of the Glasses, by reason the Number of Persons present shak'd the Room, the Society order'd me to make the Experiment at home before one or more of their Members.

*Martin Foulkes*, Esq; a very ingenious Member of the Society, did me the favour to be present when I made the Experiment at my House; where we made four Tryals in the following manner.

The whole Machine being fix'd, as above mention'd, we first let fall a Guinea and two Papers; the one placed over, and the other under it, (before any Air was pump'd out) and the Guinea came to the Bottom when the Papers were only in the Middle of the second Glas from the Top. Then having laid a Feather on the Brass-Springs close by the Guinea, we let them loose both together; and the Feather was fallen only down to the 4th part of the Length of the first Glas or  $\frac{1}{16}$  of the whole Distance, when the Guinea was got down to the Bottom of the Receiver.

We then laid two Papers and two Feathers, one of each under, and the other over the Guinea between the Springs; and having drawn out so much of the Air as to bring up the Mercury in the Gage-Tube within a quarter of an Inch of the greatest Height to which it could be then rais'd by the Pressure of the external Air, we caus'd the Bodies to fall all at once: And tho' the Papers came down to the Bottom at the same time as the Guinea, yet the Feathers, being much lighter, wanted about three Inches. But at last, having laid the Papers, Feathers, and Guinea, as before, we pump'd out all the Air, and then the Feathers, as well as the Papers, came to the Bottom of the Receiver at the same instant of time as the Guinea.

VIII. *An Account of a small Telescopical Comet  
seen at London on the 10th of June 1717.  
by Edm. Halley, LL. D. R. Soc. Secr.*

**T**HAT the Number of Comets traversing our Solar System is much greater than some, on account of the late rareness of their Appearance, have supposed it, may be collected from several small ones which have within few Years been described in the Memoirs of the *French* Royal Academy of Sciences; those diligent Observers assuring us that they discover'd one in *Sept.* 1698. another in *Febr.* 1699. a third in *April* 1702; and again a fourth in *Novemb.* 1707. none of which, as far as I can learn, were ever seen in *England*; all of them having been very obscure and without Tails, by means whereof Comets usually first shew themselves. And besides these, two other Comets with remarkably long Tails, the one in *Novemb.* 1689. the other in *Febr.* 1702. past by unobservable in these our Northern Climats, they having great South Latitude, and their Motions directed toward that Pole. Hence we may justly conclude that the Returns of Comets are much more frequent than is vulgarly reckoned, and that it is only contingent that for these 35 Years no one of them has been seen and observed by our Astronomers.

But there may be still a much greater Number of these Bodies, which by reason of their Smallness and Distance are wholly invisible to the naked Eye; so that unless Chance do direct the Telescope of a proper Observer, almost to the very Points where they are (against which there are immense Odds) it will not be possible

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for them to be discovered: And that this is not barely a Conjecture, take the following Instance.

On *Monday, June 10.* in the Evening, the Sky being very serene and calm, I was desirous to take a View of the Disk of *Mars* ( then very near the *Earth*, and appearing very glorious ) to see if I could distinguish in my 24 Foot Telescope, the Spots said to be seen on him. Directing my Tube for that purpose, I accidentally fell upon a small whitish Appearance near the Planet, resembling in all respects such a *Nebula* as I lately described in *Philos. Transact.* N<sup>o</sup> 347. but smaller. It seemed to emit from its upper part a very short kind of Radiation directed towards the East, but Northerly withal; which, considering its Situation, was nearly towards the Point opposite to the Sun. The great Light of the Moon, then very near it and also near the Full, hinder'd this *Phænomenon* from being more distinctly seen; but its Place in the Heavens was sufficiently ascertained from the Neighbourhood of *Mars*, from whom it was but about half a Degree distant towards the Southwest, the difference of Latitude being somewhat more than that of Longitude; and *Mars* being at that time in  $\mp 17^{\circ}. 30'$  with  $3^{\circ}. 48'$  South Latitude. I concluded the place thereof in  $\mp 17^{\circ}. 12'$  with  $4^{\circ}. 12'$  Lat. South, or thereabouts; the which may yet be more securely determined by help of two small fixt Stars I found near it, the more northerly of which I judged to have the same Latitude with it, and to follow it at about the Distance of six Minutes; the other Star was about four Minutes more southerly than the former, and about one Minute in consequence thereof; the Angle at the Northern Star was a little obtuse, as of about 100 Degrees, and the Distance of our *Nebula* from it *lesquielter* to the Distance of the two Stars, or rather a little more. The Reverend Mr. *James Williams*, Mr. *Alban Thomas*, and my self,

contem-

contemplated this Appearance for above an Hour, *viz.* from 10<sup>h</sup> to near twelve, and we could not be deceiv'd as to its Reality; but the Slowness of its Motion made us at that time conclude that it had none, and that it was rather a *Nebula* than a *Comet*.

However, suspecting that it might have some Motion, I attended the next Night, *June 11th*, at the same Hours and in the same Company, when with some Difficulty by reason of the Thickness of the Air, we found the two little Stars. but the *Nebula* could not at that time be seen, which we then imputed to the want of a clearer Sky. But on *Saturday, June 15.* the Moon being absent, and the Air perfectly clear, we had again a distinct View of the two Stars, with an entire Evidence that there remained no Footstep or Sign of it, in the place where we had first seen this *Phænomenon*, which we therefore now found to be a *Comet*. and that being far without the Orb of the Earth, and in it self a very small Body, it appeared only like a little Speck of a Cloud, such as would scarce have been discerned in an ordinary Telescope, much less by the naked Eye.

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IX. *An Account of Books*, I. Joannis Poleni in Gymnasio Patavino Phil. Ord. Prof. & Scient. Societatum Regalium, quæ Londini & Bero- lini sunt, Sodais, *De Motu Aquæ mixto*, Libri duo, &c. 4<sup>to</sup>. Patavii 1717.

**T**HE Subject here treated of not having hitherto fallen under the Consideration of Mathematical Writers, the Learned Author is obliged to make use of several Terms, which are either wholly new, or at least

least are apply'd in a sense somewhat different from their common Acceptation; for which reason he begins his Work with a Set of Definitions.

*Aqua mortua*, or a dead Water is that, whose Surface being every where equally distant from the *Centrum gravium*, no part of it can descend any lower, without forcing some other upward, and consequently the Whole is without Motion.

*Aqua viva*, or a running Water is that which is put into motion by the Pressure of the Incumbent Water, and whose Motion is opposed by no other Water lying in its way.

The motion of a running Water is call'd *Motus simplex*, or the simple Motion.

If a running Water moving over the Surface of a dead Water, do, by its Pressure communicate part of its Motion to the dead Water; the compound Motion with which the whole Body of the Water flows, is called *Motus mixtus*, or the mixt Motion.

If a Water at different Depths from the Surface run with different Velocities, the *mean Velocity* is that, which being the same at all Depths, will discharge the same Quantity of Water.

Next follows a short History of the Original, and Progress of the Doctrine of running Waters, the Invention of which our Author justly ascribes to the Learned *Castellus*, and defends him against *Fabretti*, who has maintain'd that *Castellus's* fundamental Proposition of the Quantity discharged being *ceteris paribus* in proportion to the Velocity, was known, and publickly taken notice of before him by *Frontinus*.

The Author allows *Castellus* to have been mistaken in determining the Velocity of Water running out at the bottom of a Vessel, he having asserted that Velocity to be as the Depth of the Water

Three Years after *Castellus's* Book came out, this Mistake was corrected by the famous *Torricellius*, who was the first that maintain'd, that the Velocity of the Water running out was in a subduplicate *Ratio* of the Depth, but gave no Demonstration of it.

This Proposition, says our Author, was confirm'd by the Experiments of *Maggiotti*, *Mariotte*, and *Guglielmini*, and has since been demonstrated by Mr. *Varignon*, by *Herman* in his *Phoronomia*, and *John Bernoulli*. as reported by *Herman* in the *Acta Lipsiensia*.

Here it may not be improper to take notice, that the Demonstrations of those three Learned Persons are all grounded upon this Supposition, that the Water running out from the Hole is prest upon by the Column of Water incumbent upon it, which may easily be demonstrated to be a Mistake. Likewise, if their Demonstrations be just, it will follow, that the first Drops of Water, which issue out from the Hole, must run with the same Velocity, as after the Water has been running some time; the Contrary of which appears to be true in Fact by the Experiments of the famous Mr. *Mariotte*.

The Author might have found a juster Account of this matter in the Writings of a Great Man, whom he cites on another Occasion; the second Edition of whose Book was come out some time before *Herman* publish'd either of those Demonstrations, and had been seen by him, as appears by his quoting it frequently, and mentioning the Difference in this very Particular between the first and second Edition.

Our Author goes on to consider the simple Motion of Water running out by a Section perpendicular to the Horizon, in the side of a Receptracle, which is always entertain'd at the same Height. He shews, that the Velocities, with which the Water issues out at different Depths,

Depths, being as the Roots of those respective Depths, may be represented by the Ordinates of a *Parabola*, whose Axis represents the entire Depth of the Water. Consequently, since the Quantities of Water, running out at different Depths, are as those Velocities, they likewise may be represented by the same Ordinates, and the Quantity of Water discharg'd from the whole Section, will be represented by the Parabolick Space; and the mean Velocity by that same Space divided by the Abscisse.

The Times, being as the Quantities of Water discharged, may be represented in the same manner as those Quantities.

Hence he derives his general Theorem, That the Quantities of Water discharged, are in a *ratio* compounded of the sesquiplicate *ratio* of the Depths of the Water, the *ratio* of the Breadths of the Section, and of that of the times of the Efflux.

The Author proceeds now to the mixt Motion of Water; in order to discover the Nature of which he has made some curious Experiments, after the following manner:

A large cylindrical Vessel, with a perpendicular Section through the side of it, was placed upright in a dead Water; so that the bottom of the Vessel was a considerable Depth below the Surface of the Water; and the Vessel was kept immovable in this situation.

Above this was fixt another Vessel, full of Water, whose Bottom was pierced with 16 Holes, exactly round, and of the same Bore, and so order'd, as to be open'd, or stop't at pleasure. The Water in this Vessel was always kept at the same Height, by means of a third Vessel, which supply'd the Water, as fast as it ran out at the round Holes in the Bottom; and a large Aperture, in the side of the second Vessel near the Top, prevented

prevented the Water in it from exceeding the due Height. To break the Force of the Water running into the two lowermost Vessels, they were each of them divided by a Board, placed perpendicular, but not reaching the Bottom, which separated the Part where the Water came in, from that where it went out.

The *Apparatus* being thus fixt, three of the round Holes in the Bottom of the second Vessel were unstopt, to let the Water run into the lower Vessel. Where not running out at the Section in the side, so fast as it came in from above, it rose to a considerable Height above the Surface of the dead Water; after which, the Efflux of the Water becoming equal to the Influx, it rose no higher.

In other Tryals the Water being suffer'd to run from 6, from 9, 12, and 15 of the round Holes, the Water rose successively to greater Heights, before the Section discharged it as fast, as it came in.

The Experiment being repeated with opening other Numbers of the round Holes, with Sections of different Breadths, and at different Depths of the dead Water, the several Heights, to which the Water rose in the Vessel, were carefully observ'd and set down.

Other Experiments were made by placing the lower Vessel on dry Ground, and the several Heights to which the Water rose in the Vessel, according as different Quantities were suffer'd to run in, were likewise observ'd, and found agreeable to the Heights deduced by Calculation from the general Theorem above-mention'd, concerning the simple Motion of Water.

The Learned Author comes now to apply these Experiments, in order to discover the Theory of mixt motion, to which end he lays down these two Hypotheses.

First, he supposes, that the Velocity of the running Water is every where in a subduplicate *ratio* of the Depth, and consequently the Quantities discharged may be represented by the Parabolick Spaces, just as in the case of the simple Motion of Water.

Secondly, that the Velocity of the dead Water, is the same at all Depths, and equal to the greatest Velocity of the running Water. Wherefore the Quantity of dead Water discharged may be represented by a Rectangle, whose Height represents the Depth of the stagnant Water, and whose Base is the greatest Ordinate of the Parabolick Space abovementioned.

Having thus contrived a way of representing the Quantities of Water discharged by the mixt Motion, as had been done before for the simple Motion of Water, our Author observes that the Velocities of the Water issuing out at different Depths, and consequently the Parabolick Spaces representing the Quantities of Water expended, must be less in the mixt, than in the simple Motion.

In order therefore to find a general Rule for determining the Proportion between the Parabolick Spaces, which represent the Quantities discharged by the mixt and simple Motion, or between the Parameters of those *Parabolas*, he draws some Observations from the foregoing Experiments, by the help of which he hopes such a Rule may be found out.

*First*, he observes. that, if the Depth of the running Water continue unchanged, a greater Depth of dead Water requires a less Parameter.

*Secondly*, That this Parameter does not decrease in so great a Proportion, as the Depth of the Water increases

*Thirdly*, That, if the Depth of the dead Water decrease, or the Depth of the running Water increase in such

such manner, that the latter becomes infinitely great in proportion to the former, then the Parameter of the mixt Motion must become equal to that of the simple Motion.

*Fourthly*, That, if the Depth of the dead Water become infinitely great in comparison of the Depth of the running Water, the Parameter of the mixt Motion vanishes, or becomes equal to nothing.

The Rule, therefore, which is to be found, ought to agree with all these Observations, and besides must produce the same Quantities of Water by Calculation, as were found by Experiment to answer to the several Depths of running and dead Water, in the above mention'd Tryals.

Upon this Foundation the Learned Author proceeds, in a tentative Method, to find his Rule, and having discover'd it, he shews by Calculation, that it answers all the Conditions before requir'd.

This Rule is express'd in a pretty high Equation, which, besides other Operations, requires the extracting the Root of the sixth Power.

From this Equation is derived another, serving to find either the Quantity of Water discharg'd, the Depth of the running, or that of the dead Water, the other two of them being given; as likewise a third Equation, to find the mean Velocity.

Our Author goes on to shew the Usefulness and Necessity of considering the Doctrine of mixt Motion, in all Questions relating to the Course of Rivers, the Quantities of Water which they discharge, the enlarging or narrowing their Outlets, the scouring and deepening their Channels, and the Motion of the Tides in Harbours. These he illustrates by several Deductions from the Equations above mention'd; to render which of greater Evidence, it were to be wish't, that those Equations



were built upon a more solid Foundation than a tentative *Calculus*; and that Allowance had been made for the Velocity impreſt upon the preceding Water in Rivers, by the *impetus* of that which follows, which is omitted by the Author in his Theory, both of mixt and ſimple Motion.

In the Second Book, this Learned Writer propoſes the State of the *Laguna* of *Venice*, as a proper Example, to demonſtrate the Uſefulneſs of his new Theory. He conſiders very minutely the ſeveral Cauſes of choaking up the *Laguna*, examines the Methods propoſed by various Authors for ſcouring and keeping it clear, ſome of which he rejects as impracticable on account of the Expence, others as uſeleſs, or prejudicial; and laſtly delivers his own Opinion.

The principal Cauſes, which he aſſigns, of filling up the *Laguna*, are the Rivers running into it, and the Sea.

The Rivers, which enter it, ariſing out of the *Alps*, and running down with great Rapidity, carry with them, eſpecially after Rains, great Quantities of Soil, which is eaſily ſuſpended in the Water, ſo long as that Swiftneſs of Motion continues. But when they come into the *Laguna*, the Water, upon extending it ſelf over that vaſt Surface, looſes almoſt all its Velocity, and conſequently the Soil and Filth, which before it carry'd with it, ſubſides in great Quantities to the Bottom.

The Remedy our Author propoſes for this Inconvenience, is either wholly to divert the Courſe of the Rivers, and carry them, by another Way, directly into the Sea; or at leaſt, to ſecure their Outlets with Sluices, ſo as to ſuffer them to paſs into the *Laguna*, when their Waters are clear; but after great Rains, when they run foul and turbid, to ſtop their Paſſage that way, and let them out by the other Channel into the Sea.

The

The second principal Cause of choaking up the *Laguna*, is the Sea. Concerning which our Author observes, that the Tide of Flood sets into the *Laguna* from along the Coast of *Istria* and *Friuli*, where it is perpetually washing away the Land in great Quantities, with which, and the Sand which it raises upon high Winds in the Shallows near the Shore, it enters the *Laguna* exceedingly turbid and foul; especially, when the Wind blows hard at South-East, at which times the Tide of Flood is several Hours longer than the Ebb. This occasions very high Tides in the *Laguna*, and a great part of the Water which enters by the Flood, not being carry'd out by the subsequent Ebb, has the more time to discharge its Soil and Sand in the *Laguna*.

This is an Enemy very hard to deal with, however our Author proposes some Works of strong Piles, and large Stones thrown in between them, to be carried directly forward into the Sea, in order to break the Violence of the Waves, and prevent their washing and carrying away the Land.

He seems likewise to favour a Proposal made by the late famous *Guglielmini*, and some others, to let the Tide enter the *Laguna* by more Passages than it is to go out at, in order to make it run out with a greater Velocity, and thereby scour and deepen the Channels. But he thinks this Contrivance will scarcely perform all that is expected from it; besides that, it will be attended with great Difficulties in making Works, and Flood-gates of a sufficient Strength, to resist the Violence of the Waters.

He occasionally combats the Opinion of *Guglielmini*, and most other Mathematicians who have thought upon the Subject, that in order to give a greater Velocity to the Water of a River, thereby to scour and cleanse the Channel, it is proper to make the Outlet narrower.

narrower. This our Author maintains to be oftner false, than true, and endeavours to shew from his Theorem above-mention'd, that making the Outlet narrower, will frequently cause the *mean Velocity* of the Waters to become less than it was before. But whether a Proposition of such Consequence, and seemingly so well supported by Reason and Experience, ought to be condemn'd upon the Authority of a Theorem founded only upon a tentative Calculation, must be left to the Judgment of the Learned.

II. *Apollonii Pergæi Conicorum Libri Octo, & Sereni Antiffensis de Sectione Cylindri & Coni Libri duo. Fol. Reg. E Theatro Oxon. 1710.*

THE worthy Curators of the Oxford Press having obliged the Publick with a very elegant Edition of the Works of *Euclid*, *Græco-Latinè*, were pleas'd further to proceed in the laudable Intention of giving the rest of the ancient *Greek Mathematicians* in the same beautiful Form: In this Design they were chiefly animated by the late learned and beneficent Dean of *Christ Church*, Dr. *Henry Aldridge*, who pitching upon *Apollonius*, as most proper to succeed *Euclid*, engaged the two *Savilian* Professors to take upon them the Care and Pains of the Edition: Dr. *David Gregory* promising his Assistance as to the first Four Books, which are still extant in *Greek*; and Dr. *Edm. Halley* undertaking to translate the Fifth, Sixth, and Seventh Books out of *Arabick* (in which Language they were only to be found) and to endeavour to restore the Eighth, long since wholly lost. But Dr. *Gregory* soon after dying, the Care of the Whole devolved on Dr. *Halley*, who hath spared no Pains to render the Work complete.

He in his Preface tells us what Helps he had to perfect the Text, That he had the use of two *Greek MSS.* of the first Four Books, one of which was Sir *Henry Savil's*, and is in the *Savilian Study* at *Oxford*, the other is now in the  
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Royal Society's *Museum*, having been lately presented thence by that skilful Mathematician Mr. *William Jones*, F. R. S. That he had only one Manuscript of *Eutocius's* Commentary, out of the *Bodley Library*; and two Greek Copies, from the *Savilian Study*, of *Pappus's* Collections, out of whose 7th Book he took the *Lemmata*, which serve as a Comment on the more difficult Places of his Author; and that he was forced to revise and correct the Mistakes and Improprieties of the Latin Translation of *Commandine*.

As to the latter Books, which were only in *Arabick*, he informs us, that he made use of the *Bodley Transcript* of a Manuscript that is at *Leyden*, which it self is a late Copy of that ancient *Arabick* Book of the *Conicks*, heretofore *Golius's*, but since purchased by that great Patron of Universal Learning, *Narcissus* late Primate of *Ireland*, who was pleased to favour him so far as to send over into *England* this Original Book whereby he not only amended several Faults committed by the Copyists in a double Transcription, but was also assured that this *Arabick* Book was a verbal Translation from the Greek; the same Schemes marked with the same Letters, and the whole Context being the same in the first four Books of it, as in the Greek *Apollonius*. This valuable Manuscript, with about 800 others, *Oriental* and *Greek*, has since, by the Donation of that most venerable Prelate, made a noble Accession to the *Bodley Library*, wherein it is now deposited. It appears by an *Epigraph* at the end, to have been written in the Year of Christ 1303. and to have been a Copy of a Translation of the *Conicks*, made some Ages before by *Thebit Ben Corab*, but then newly revised by that famous *Persian* Mathematician *Nasir-eddin*, who flourish'd about the middle of our thirteenth Century.

Besides this, the Editor tells us, that on occasion he consulted another *Arabick* Manuscript (heretofore *Ravius's*) of great Antiquity, being an *Epitome* of the same Books by *Abdolmelec* of *Schiraz*, every where agreeing in the Order and Argument with the former, but abridg'd. So that having had these Helps, he is in hopes that he has so far retrieved those Three Books of *Apollonius*, that the Loss of the Greek Text may henceforth be less lamented.

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The Eighth Book of these Conicks, was wanting in the Greek Copies even before the Translation of them into *Arabic* by *Thebit*: But it having been observ'd that there was a very near relation between the Arguments of the VIIth and VIIIth Books, for that the same *Lemmata* of *Eppus* were common to them both, which are different to all the rest, it seem'd that the *Theoremata Diuistica* of the VIIth Book were designed to determine the Limits of the *Problemata Diuistica* of the VIIIth; and therefore supposing what those Problems might have been, and their Order from that of the said Theorems, Dr. *Halley* has in XXXIII Propositions given the *Analyses* and *Syntheses* of them, after the Method of the Ancients, every where following the Steps of *Apollonius* to be found in his VIIth Book. This he calls *Conicorum Liber Octavus restitutus*, and may serve the turn, till such time as the Original Eighth Book come to light; if that be not now to be despair'd of.

Because of the Affinity of the Subject, he hath subjoin'd the two Books of *Serenus Antissensis*, the Greek Text of which was never before in print. This was procured by the abovesaid Reverend Dean of *Christchurch*, Dr. *Aldrich*, in a collated Copy of three Manuscripts extant in the King's Library at *Paris*, and by him, according to his wonted Goodness and Generosity, freely communicated for the use of the Publick. To this also is added the Latin Translation of *Commandine*, which in many Cases needed Castigation.

As to the Authors themselves little needs be said, they having stood the Test of so many Ages, and been highly valued by the Learned in all Times, especially the Conicks, justly esteem'd a Masterpiece in the Geometry of the Ancients: So that it may seem strange, that a Book so excellent in its kind should not till now have been printed in its native *Greek*, a Tongue so peculiarly adapted to Mathematical Purposes. But this present Edition may make ample Amends, the Paper and the Elegance and Correctness of the Print being remarkable. The Book is now to be had of Mr. *Christopher Bateman* in *Pater-noster Row*, *London*.

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# PHILOSOPHICAL TRANSACTIONS.

For the Months of *Jan. Feb. March* and *Apr.* 1718.

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I. *Considerations on the Change of the Latitudes of some of the principal fixt Stars.* By Edmund Halley, R. S. Sec.

**H**AVING of late had occasion to examine the quantity of the Precession of the Equinoctial Points, I took the pains to compare the Declinations of the fixt Stars delivered by *Ptolomy*, in the 3<sup>d</sup> Chapter of the 7<sup>th</sup> Book of his *Almag.* as observed by *Timocharis* and *Aristyllus* near 300 Years before *Christ*, and by *Hipparchus* about 170 Years after them, that is about 130 Years before *Christ*, with what we now find: and by the result of very many Calculations, I concluded that the fixt Stars in 1800 Years were advanced somewhat more than 25 degrees in Longitude, or that the Precession is somewhat more than 50" *per ann.* But that with so much uncertainty, by reason of the imperfect Observations of the Ancients, that I have chosen in my Tables to adhere to the even proportion of five Minutes in six Years, which from other Principles we are assured is very near the Truth. But while I was upon this Enquiry, I was surprized to find the Latitudes of three of the principal Stars in Heaven directly to contradict the supposed greater *Obliquity* of the *Ecliptick*, which seems confirmed by the Latitudes of most of the rest; they being set down in the old Catalogue, as if the Plain of the Earths Orb had changed its Situation, among the fixt Stars, about 20' since the time of *Hipparchus*. Particularly all the Stars in *Gemini* are put down, those to the *Northward* of the *Ecliptick*, with so much less Latitude than we find, and those to the *Southward* with so much more *Southerly*  
 Lati-

Latitude. Yet the three Stars *Palilicium* or the Bulls Eye, *Sirius* and *Arcturus* do contradict this Rule directly: for by it, *Palilicium* being in the days of *Hipparchus* in about 10 *gr* of *Taurus* ought to be about 15 Min. more *Southerly* than at present. and *Sirius* being then in about 15 of *Gemini* ought to be 20 Min. more *Southerly* than now: yet *à contra* *Ptolomy* places the first 20 Min. and the other 22 more *Northerly* in Latitude than we now find them. Nor are these errors of Transcription, but are proved to be right by the declinations of them set down by *Ptolomy*, as observed by *Timocharis*, *Hipparchus* and himself, which shew that those Latitudes are the same as those Authors intended. As to *Arcturus*, he is too near the Equinoctial Colure, to argue from him concerning the change of the Obliquity of the Ecliptick, but *Ptolomy* gives him 33' more *North* Latitude than he now has; and that greater Latitude is likewise confirmed by the Declinations delivered by the abovesaid Observers. So then all these three Stars are found to be above half a degree more *Southerly* at this time than the Antients reckoned them. When on the contrary at the same time the bright Shoulder of *Orion* has in *Ptolomy* almost a degree more *Southerly* Latitude than at present. What shall we say then? It is scarce credible that the Antients could be deceived in so plain a matter, three Observers confirming each other. Again these Stars being the most conspicuous in Heaven, are in all probability the nearest to the Earth, and if they have any particular Motion of their own, it is most likely to be perceived in them, which in so long a time as 1800 Years may shew it self by the alteration of their places, though it be utterly imperceptible in the space of a single Century of Years. Yet as to *Sirius* it may be observed that *Tycho Brahe* makes him 2 Min. more *Northerly* than we now find him, whereas he ought to be above as much



much more *Southerly* from his Ecliptick, (whose Obliquity he makes  $2\frac{1}{2}$  greater than we esteem it at present) differing in the whole  $4\frac{1}{2}$  Min. One half of this difference may perhaps be excused, if refraction were not allowed in this Case by *Tycho*; yet two Minutes, in such a Star as *Sirius*, is somewhat too much for him to be mistaken

But a further and more evident proof of this change is drawn from the Observation of the application of the Moon to *Palilicium* Anno Christi 509 Mart. 11°. when in the beginning of the Night the Moon was seen to follow that Star very near, and seemed to have Eclipsed it, ἐπέβαλε γὰρ ὁ ἀστὴρ τῆς ὥξης πλεὺς διχόλομιν μέρεϊ τῆς κύβης περιφερείας τῆς περιώσιμους μέρου. i. e. *Stella apposta erat parti per quam viscabatur limbus Lune illuminatus*, as *Bullialdus*, to whom we are beholden for this Antient Observation has translated it. Now from the undoubted principles of Astronomy, it was impossible for this to be true at *Athens*, or near it, unless the Latitude of *Palilicium* were much less than we at this time find it. *Vide Bullialdi Astr. Philolaica, pag 172.*

This Argument seems not unworthy of the *Royal Society's* Consideration, to whom I humbly offer the plain Fact as I find it, and would be glad to have their Opinion.

But whether it were really true, that the Obliquity of the Ecliptick was, in the time of *Hipparchus* and *Ptolemy*, really 22 Min. greater than now, may well be questioned; since *Pappus Alexandrinus*, who lived but about 200 Years after *Ptolemy*, makes it the very same that we do. *Vide Pappi Collect. Lit. VI. Prop. 35.*

II. *An Account of some Experiments shown before the Royal Society ; with an enquiry into the cause of the Ascent and Suspension of Water in Capillary Tubes.* By James Jurin, M. D. and R. Soc. S.

SOME Days ago a Method was proposed to me by an ingenious Friend, for making a perpetual Motion, which seem'd so plausible, and indeed so easily demonstrable from an Observation of the late Mr. *Hawksbee*, said to be grounded upon Experiment. that, tho' I am far from having any Opinion of attempts of this Nature, yet, I confess, I could not see why it should not succeed. Upon tryal indeed I found my self disappointed. But as searches after things impossible in themselves are frequently observ'd to produce other discoveries unexpected by the Inventer; so this Proposal has given occasion not only to rectify some mistakes into which we had been led, by that ingenious and useful Member of the *Royal Society* above named, but likewise to detect the real Principle, by which Water is rais'd and suspended in Capillary Tubes, above the Level.

*My Friend's Proposal was as follows.*

*Fig 1.* Let  $ABC$  be a capillary Siphon, compos'd of two Legs  $AB, BC$ , unequal both in length and Diameter; whose longer and narrower Leg  $AB$  having its orifice  $A$  immerst in Water, the Water will rise above the Level, till it fills the whole Tube  $AB$ , and will then continue suspended. If the wider and shorter Leg  $BC$ , be in like manner immerst, the Water

B b b b b b

will

will only rise to some height as  $FC$ , less than the entire height of the Tube  $BC$ .

This Siphon being fill'd with Water. and the Orifice  $A$  sunk below the Surface of the Water  $DE$ , my Friend reasons thus.

Since the two Columns of Water  $AB$  and  $FC$ , by the Supposition, will be suspended by some Power acting within the Tubes they are contain'd in, they cannot determine the Water to move one way, or the other. But the Column  $BF$ , having nothing to support it, must descend, and cause the Water to run out at  $C$ . Then the pressure of the Atmosphere driving the Water upward through the Orifice  $A$ , to supply the Vacuity, which would otherwise be left in the upper part of the Tube  $BC$ , this must necessarily produce a perpetual Motion, since the Water runs into the same Vessel, out of which it rises. But the Fallacy of this reasoning appears upon making the Experiment.

*Exp. 1.* For the Water, instead of running out at the Orifice  $C$ , rises upward towards  $F$ , and running all out of the Leg  $BC$ , remains suspended in the other Leg to the height  $AB$ .

*Exp. 2.* The same thing succeeds upon taking the Siphon out of the Water, into which its lower Orifice  $A$  had been immerst, the Water then falling in drops out of the Orifice  $A$ , and standing at last at the height  $AB$ . But in making these two Experiments it is necessary that  $AG$  the difference of the Legs exceed  $FC$ , otherwise the Water will not run either way.

*Exp. 3.* Upon inverting the Siphon full of Water, it continues without Motion either way.

The reason of all which will plainly appear, when we come to discover the Principle, by which the Water is suspended in Capillary Tubes.

Mr.

Mr. *Hawksbee's* Observation is as follows.

*Fig. 2.* Let  $ABFC$  be a capillary Siphon, into the which the Water will rise above the Level to the height  $CF$ , and let  $BA$  be the depth of the Orifice of its longer Leg below the Surface of the Water  $DE$ . Then the Siphon being fill'd with Water, if  $BA$  be not greater than  $CF$ , the Water will not run out at  $A$ , but will remain suspended.

This seems indeed very plausible at first sight. For since the Column of Water  $FC$  will be suspended by some power within the Tube, why should not the Column  $BA$ , being equal to, or less than the former, continue suspended by the same Power?

*Exp. 4.* In fact, if the orifice  $C$  be lifted up out of the Water  $DE$ , the Water in the Tube will continue suspended, unless  $BA$  exceed  $FC$ .

*Exp. 5.* But when  $C$  is never so little immerst in the Water, immediately the Water in the Tube runs out in drops at the Orifice  $A$ , tho' the length  $AB$  be considerably less than the height  $CF$ .

Mr. *Hawksbee* in his Book of Experiments has advanced another Observation, namely, that the shorter Leg of a Capillary Siphon, as  $ABFC$ , must be immerst in the Water to the depth  $FC$ , which is equal to the height of the Column, that would be suspended in it, before the Water will run out at the longer Leg.

*Exp. 6.* From what mistake this has proceeded, I cannot imagine; for the Water runs out at the longer Leg, as soon as the Orifice of the shorter leg comes to touch the Surface of the stagnant Water, without being at all immerst therein.

Having proceeded thus far in obedience to the commands of this Illustrious Society, I beg leave to go a little farther, and to enquire into the cause of the ascent and suspension of Water in capillary Tubes.

That this Phenomenon is no way owing to the pressure of the Atmosphere, has been I think sufficiently prov'd by Mr. *Harksbee's* Experiments.

And that the cause assign'd by the same ingenious and inquisitive Person, namely the attraction of the concave Surface, in which the suspended Liquor is contain'd, is likewise insufficient for producing this effect, I thus demonstrate.

Since in every capillary Tube the height, to which the Water will spontaneously ascend, is reciprocally as the Diameter of the Tube, it follows, that the Surface containing the suspended Water in every Tube is always a given Quantity : but the Column of Water suspended is, as the Diameter of the Tube. Therefore, if the attraction of the containing Surface be the cause of the Waters suspension ; it will follow, that equal causes produce unequal effects, which is absurd.

To this it may perhaps be objected, that, in two Tubes of unequal Diameters, the circumstances are different, and therefore the two Causes, tho' they be equal in themselves, may produce effects that are unequal. For the lesser Tube has not only a greater Curvature, but those parts of the Water, which lie in the middle of the Tube, are nearer to the attracting Surface, than in the wider. But from this if any thing follows, it must be, that the narrower Tube will suspend the greater quantity of Water, which is contrary to Experiment. For the Columns suspended are as the Diameters of the Tubes.

But as Experiments are generally more satisfactory in things of this nature, than Mathematical reasonings, it may not be amiss to make use of the following, which appear to me to contain an *Experimentum Cru-*

*fig.*

*Fig.*

*Fig. 3:* The Tube  $CD$  is composed of two Parts; in the wider of which the Water will rise spontaneously to the height  $BF$ , but the narrower Part, if it were of a sufficient length, would raise the Water to a height equal to  $CD$ .

*Exp. 7.* This Tube being fill'd with Water, and the wider end  $C$  immerst in the stagnant Water  $AB$ , the whole continues suspended.

*Exp. 8. Fig. 4.* The narrower end being immerst, the Water immediately subsides, and stands at last at the height  $DG$  equal to  $BF$ .

From which it is manifest, that the suspension of the Water in the former of these Experiments is not owing to the attraction of the containing Surface: since, if that were true, this Surface being the same, when the Tube is inverted, would suspend the Water at the same height.

Having shown the insufficiency of this Hypothesis, I come now to the real cause of that Phenomenon, which is the attraction of the Periphery, or Section of the Surface of the Tube, to which the upper Surface of the Water is contiguous and coheres.

For this is the only part of the Tube, from which the Water must recede upon its subsiding, and consequently the only one, which by the force of its cohesion, or attraction, opposes the descent of the Water.

This likewise is a cause proportional to the effect, which it produces; since that Periphery, and the Column suspended, are both in the same proportion as the Diameter of the Tube.

Tho' from either of these particulars it were easy to draw a just Demonstration, yet to put the matter out of all doubt, it may be proper to confirm this assertion, as we have done the former, by actual Experiment:

*Fig.*

*Fig. 5.* Let therefore *EDC* be a Tube, like that made use of in the 7th and 8th Experiments, except that the narrower Part is of a greater length; and let *AF* and *BG* be the heights, to which the Water would spontaneously rise in the two Tubes *ED* and *DC*.

*Exp. 9.* If this Tube have its wider Orifice *C* immerst into the Water *AE*, and be fill'd to any height less than the length of the wider Part, the Water will immediately subside to a level with the point *G*; but if the Surface of the contain'd Water enter never so little within the smaller Tube *ED*, the whole Column *DC* will be suspended, provided the length of that Column do not exceed the height *AF*.

In this Experiment it is plain that there is nothing to sustain the Water at so great a height, except the contact of the Periphery of the lesser Tube, to which the upper Surface of the Water is contiguous. For the Tube *DC*, by the Supposition, is not able to support the Water at a greater height than *BG*.

*Exp. 10 Fig. 6.* When the same Tube is inverted, and the Water is rais'd into the lower extremity of the wider Tube *CD*, it immediately sinks, if the length of the suspended Column *DH* be greater than *GB*; whereas in the Tube *DE* it would be suspended to the height *AF*. From which it manifestly appears, that the suspension of the Column *DH* does not depend upon the attraction of the Tube *DE*, but upon the Periphery of the wider Tube, with which its upper Surface is in contact.

For the sake of those, who are pleas'd with seeing the same thing succeed in different manners, we subjoin the two following Experiments, which are in substance the same with the 9th and 10th.

*Fig. 7.* *ABC* is a Siphon, in whose narrower, and shorter Leg *AB*, if it were of a sufficient length, might  
be

be suspended a Column of Water of the height  $EF$ ; but the longer and wider Leg  $BC$  will suspend no more than a Column of the length  $GH$ .

*Exp. 11.* This Siphon being fill'd with Water, and held in the same Position as in the Figure, the Water will not run out at  $C$  the Orifice of the longer Leg, unless  $DC$ , the difference of the Legs  $AB$  and  $BC$ , exceed the length  $EF$ .

*Fig. 8. Exp. 12.* If the narrower Leg  $BC$  be longer than  $AB$ , the Water will run out at  $C$ , if  $DC$  the difference of the Legs exceed  $EF$ ; otherwise it will remain suspended.

In these two Experiments it is plain, that the Columns  $DC$  are suspended by the attraction of the Peripheries at  $A$ , since their lengths are equal to  $EF$ , or to the length of the Column, which by the supposition those Peripheries are able to support; whereas the Tubes  $BC$  will sustain Columns, whose lengths are equal to  $GH$ .

Tho' these Experiments seem to be conclusive, yet it may not be improper to prevent an Objection, which naturally presents it self, and which at first view may be thought sufficient to overturn our Theory.

*Fig. 5.* For since a Periphery of the Tube  $ED$  is able to sustain no more than a Column of the length  $AF$ , contain'd in the same Tube; how comes it to sustain a Column of the same length in the wider Tube  $DC$ , which is as much greater than the former, as the Section of the wider Tube exceeds that of the narrower?

*Fig. 6.* Again, if a Periphery of the wider Tube  $DC$  be able to sustain a Column of Water in the same Tube, of the length  $BG$ ; why will it support no more than a Column of the same length in the narrower Tube  $ED$ ?

Which



Which Queries may likewise be made with regard to the 11th and 12th Experiments.

The answer is easy, for the Moments of those two Columns of Water are precisely the same, as if the sustaining Tubes *ED* and *CD*, were continued down to the Surface of the stagnant Water *AB*; since the velocities of the Water, where those Columns grow wider, or narrower, are to the velocities at the attracting Peripheries, reciprocally as the different Sections of the Columns.

*Fig. 9. Exp. 13.* From which consideration arises this remarkable Paradox. That a Vessel being given of whatsoever Form, as *ABC*, and containing any assignable quantity of Water, how great soever; that whole quantity of Water may be suspended above the Level, if the upper part of the Vessel *C* be drawn out into a capillary Tube of a sufficient fineness.

But whether this Experiment will succeed, when the height of the Vessel is greater than that, to which Water will be rais'd by the pressure of the Atmosphere, and how far it will be alter'd by a *Vacuum*, I may perhaps have the honour of giving an account to the *Society* some other time, not being perfectly satisfy'd with those Tryals which I have hitherto had the opportunity of making.

Having discover'd the cause of the suspension of Water in capillary Tubes, it will not be difficult to account for the seemingly spontaneous ascent of it. For, since the Water, that enters a capillary Tube as soon as it's Orifice is dipt therein, has it's gravity taken off by the attraction of the Periphery with which it's upper Surface is in contact, it must necessarily rise higher, partly by the pressure of the stagnant Water, and partly by the attraction of the Periphery immediately above that, which is already contiguous to it.

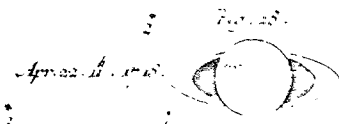
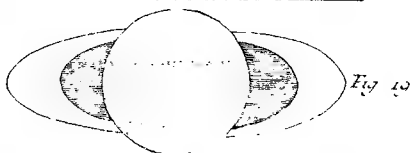
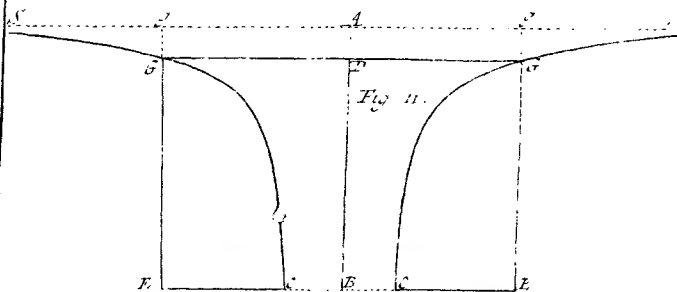
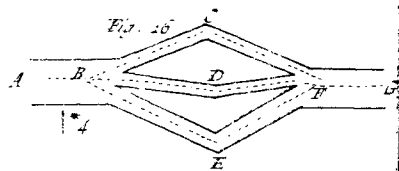
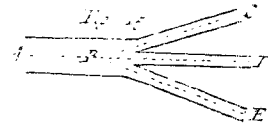
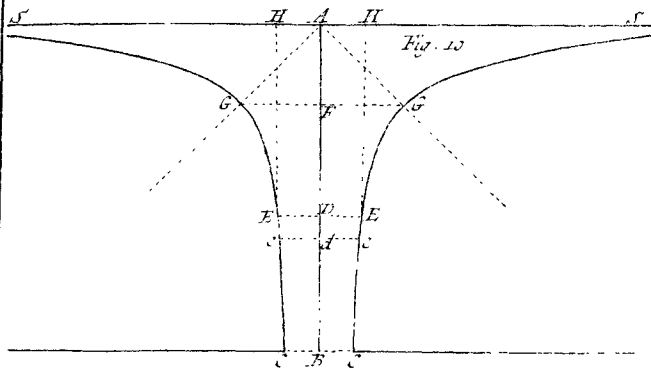
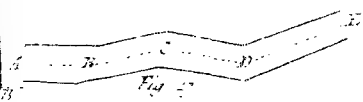
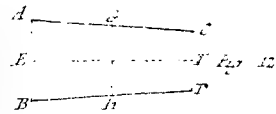
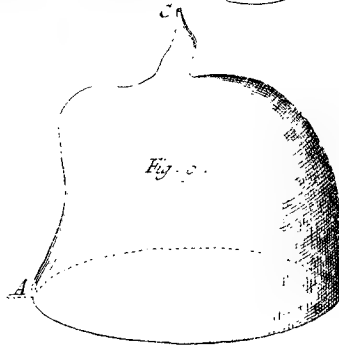
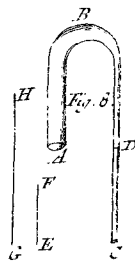
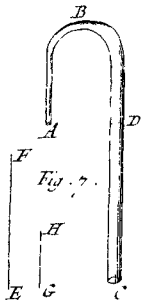
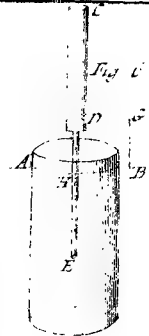
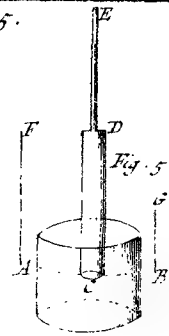
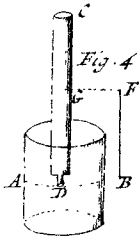
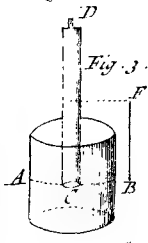
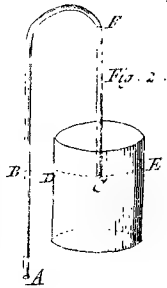
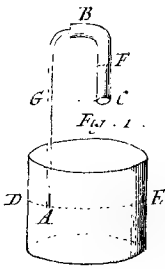
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It might now be shown, how naturally the various, and seemingly contrary appearances of the above mention'd Experiments are deducible from this Theory ; but this is so easy, that it is needless to insist upon it ; and our discourse upon this minute Subject has been already so tedious, that we could scarce hope for Pardon, unless it were directed to those, who are sensible to how many of the greater, and more considerable, Phænomena of Nature this Doctrine is applicable.

*P S.* When this Paper was reading before the Society, I found that our incomparable President was already acquainted with the above-mentioned Principle, and I have since met with several Passages in the 3<sup>rd</sup> Query subjoin'd to the late Edition of his *Opticks* which plainly shew, that he was Master of it, when they were written.

I must do the same Justice to that excellent Mathematician Mr. *John Machin*, Professor of Astronomy in *Gresham College*.

To these two worthy Persons I am obliged for the following Observation, That, what I call a Periphery, or Section of the concave surface of the Tube, is really a small Surface, whose Base is that Periphery, and whose height is the distance, to which the attractive power of the Glass is extended.



III. *De Motu Aquarum fluentium. Authore eodem*  
*D. Jacobo Jurin, M. D.*

**A** Quæ Motum ex imi vasis foramine defluentis sæpe videmus, tum in ipsâ re Hydraulica, tum in ejus Principiis ad Oeconomiam Animalem applicandis, aliis cum Potentiis comparari. Cujus Motus quantitatem cum hactenus nemo, quod sciam, recte determinaverit, usurpare solent ejus loco scriptores Hydraulici Columnæ aqueæ pondus foraminis incumbentis. Quod qui faciunt, id sane neutiquam animum advertunt fieri omnino non posse, ut Motus aliquis cum pondere quiescente conferatur. Poterit autem Aquæ defluentis Motus facili opera definiri hunc in modum.

*Fig. 10.* Sit  $SHAH S$  Aquæ superficies infinita,  $CC$  foramen circulare in fundo factum.  $AB$  recta perpendicularis per foraminis centrum ducta,  $SGCCGS$  Columna sive Cataracta Aquæ per foramen  $CC$  decurrentis,  $SGC$  Curva. cujus rotatione circa Axem  $AB$  generatur Solidum, sive Cataracta,  $SGCCGS$  Aqua enim cum libere, & motu accelerato descendat ad normam corporum omnium gravium, necessariò in minorem amplitudinem contrahitur, prout majorem velocitatem acquirit inter cadendum, & profluit ex foramine  $CC$  ea cum velocitate, quæ cadendo ab altitudine  $AB$  comparatur.

Velocitas autem corporis gravis cadendo genita, ex *Galilei* demonstratis, rationem obtinet subduplicatam altitudinis unde cecidit. Quare, si ducatur ad Curvam  $SGC$  Ordinata quævis  $DE$ . atque ipsa  $DE$  vocetur  $y$ , &  $AD$   $x$ , exponetur velocitas Aquæ in sectione  $EE$   
per

per  $\sqrt{x}$ , & Factum ex ea velocitate ducta in ipsam sectionem per  $\sqrt{x} \times y^2$ .

Quod Factum est ut moles Aquæ dato temporis spatio per eam sectionem transeuntis; cumque eadem Aquæ moles dato tempore per singulas Cataractæ sectiones transeat, proinde Factum illud perpetuo sibi constabit, eritque  $\sqrt{x} \times y^2 = 1$ , &  $xy^4 = 1$ .

Quæ est Æquatio Curvæ  $SGC$ , cujus partem, intra datum vas comprehensam, delineavit, ejusdemque Æquationem non obscure indicavit Magnus *Newtonus*, *Prop. 36. Lib. 2. Princip.* qui primus omnium veram Aquæ effluentis velocitatem, ex genuinis Principiis deductam, Orbi Literato exposuit.

Est autem ipsa Curva Hyperbolicides quarti Ordinis, cujus altera Asymptotos est recta  $AS$  ad Horizontem parallela, altera  $AB$  eidem perpendicularis.

Hujus Potestas est Quadrato-Cubus Ordinatæ  $FG$ , ductæ ad punctum  $G$ , ubi recta  $AG$ , bisecans angulum ab Asymptotis comprehensum, Curvæ occurrit.

Spatium  $S A D E S$ , inter Curvam  $SGE$ , Ordinatam  $DE$  & Asymptotos  $AD$ ,  $AS$  inclusum, æquale est quatuor partibus tertiis Rectanguli  $HD$ , sub Abscissâ  $AD$  & Ordinata  $DE$  contenti. Estque proinde Spatium  $SHE$  pars tertia ejusdem Rectanguli.

Solidum  $SGE EGS$ , convolutione spatii  $S A D E S$ , circa Axem  $AD$ , generatum, duplum est Cylindri incumbenti sectioni  $EE$ . Unde Solidum cavum, quod gignit conversio spatii  $S H E G S$ , circa eundem Axem, Cylindro incumbenti æquale est. Quæ omnia facili calculo inveniuntur per Methodum Fluxionum inversam.

### *Theorema I.*

Aquâ ex vase amplitudinis infinitæ, per foramen circulare in fundo factum, decurrente, Motus totius Cataractæ aquæ Horizontem versus æqualis est Motui Cy-

lindri aquei. sub ipso foramine & altitudine Aquæ, cujus velocitas æquet velocitatem Aquæ per foramen effluentis; vel æqualis est Motui molis Aquæ, quæ dato quovis tempore effluit, cujus ea sit velocitas, qua percurratur eodem dato tempore spatium æquale altitudini Aquæ.

*Demonstratio primæ partis.*

Ducatur ad Curvam  $SGC$  alia Ordinata  $de$ , priori  $DE$  quam proxima.

Curvâ circa Axem  $AB$  conversâ, generabunt Ordinatæ  $DE$ ,  $de$ , Circulos duos, quibus intercipitur Solidum nascens  $EEe$ . Id solidum æquale est Facto ex altitudine  $Dd$  ducta in sectionem  $EE$ , & Motus ejus æquatur Facto ex ipso solido ducto in velocitatem ejusdem, sive Facto ex altitudine  $Dd$ , sectione  $EE$ , & velocitate Aquæ in ea Sectione. Cumque supra ostentum sit, Factum ex quavis Sectione Cataractæ & velocitate Aquæ in ea Sectione, quantitatem esse constantem, erit proinde Motus totius Cataractæ æqualis Facto ex quantitate illa constante ducta in Summam omnium altitudinum  $Dd$ , sive in ipsam  $AB$ , hoc est, Motui Cylindri sub ipso foramine & altitudine Aquæ, cujus velocitas æquet velocitatem Aquæ per foramen effluentis.  $\mathcal{Q}. E. D.$

*Corol. 1.* Data altitudine Aquæ, erit Motus Cataractæ in ratione foraminis.

2. Dato foramine, erit Motus Cataractæ in ratione fescuplicata altitudinis, sive in ratione triplicata velocitatis, qua Aqua per foramen exit.

3. Dato Motu Cataractæ, erit foramen reciprocè in ratione fescuplicata altitudinis, vel reciprocè in ratione velocitatis triplicata.

*Demonstratio secundæ partis.*

Moles Aquæ dato tempore effluentis est ad Cylindrum sub ipso foramine & altitudine Aquæ, ut longitudo quam Aqua effluens æquabili velocitate dato isto tempore

tempore percursura sit, ad altitudinem Aquæ. Cumque velocitas, quæ tribuitur moli Aquæ effluentis, sit ad velocitatem Cylindri reciproce in eadem ratione, erunt Motuum quantitates utrinque æquales. *Q. E. D.*

*Corol. 1.* Data altitudine Aquæ & mole effluente, Motus Cataractæ est in ratione inversa temporis quo ista moles effluit.

1. Data altitudine & tempore, Motus Cataractæ est ut moles Aquæ tempore isto effluentis.

3. Dato tempore & mole Aquæ effluentis, erit Motus Cataractæ in ratione altitudinis.

4. Dato Motu Cataractæ & altitudine, moles effluens est in ratione temporis.

5. Dato Cataractæ Motu & mole Aquæ effluentis, altitudo est ut tempus.

6. Dato tempore & Motu Cataractæ, erit Aquæ effluentis moles reciproce ut altitudo.

### *Theorema II.*

*Fig. 11.* Si capiatur  $BA$ , quæ sit ad  $BD$ , ut  $DG^+$  ad  $DG^+ - BC^+$ ; Aqua decurrente ex dato vase Cylindrico semper pleno  $GGE E$ , per foramen circulare  $CC$  in fundo medio factum, Motus Cataractæ aquæ Horizontem versus æqualis erit Motui Cylindri sub foramine & altitudine  $AB$ , cujus velocitas æquet velocitatem Aquæ per foramen exeuntis; vel erit æqualis Motui molis Aquæ quæ dato quovis tempore effluit, cujunque ea sit velocitas, qua percurretur eodem dato tempore spatium æquale altitudini  $AB$ .

#### *Demonstratio primæ partis.*

Ducatur  $AS$  ipsi  $DG$  parallela, & Asymptotis  $AS$ ,  $AB$ , per puncta  $G$ ,  $C$  descripta concipiatur Curva *Newtoniana*  $SGC$ .

Ut constet Aquæ altitudo, supplendus est exeuntis locus Cylindro aquico  $ggGG$ , descendente cum ea velocitate

locitate uniformi, quæ acquiritur cadendo ab  $A$  ad  $D$ , quemadmodum docet Vir incomparabilis Propositione prædicta.

Motui hujus Cylindri æquatur, per Theorema superius, Motus Cataractæ  $SSGG$ . Ergo Motus Aquæ descendens, cum sit compositus ex Motu Cylindri aquei  $ggGG$ , & Motu Cataractæ  $GGCC$ , æqualis est Motui Cataractæ integræ  $SGCCGS$ , *h. e.* per Theorema primum, Motui Cylindri aquei sub foramine & altitudine  $AB$ , cujus velocitas æqualis sit velocitati Aquæ per foramen decurrentis.  $\mathcal{Q} E. D.$

Pars secunda sequitur ex priorē.

*Corol. I.* Oriuntur hinc omnia Propositionis præcedentis Corollaria, substituendo altitudinem  $AB$ , pro Aquæ altitudine.

2. Si vas alia figura fuerit, atque Cylindrica; aut foraminis figura pro circulari fuerit quadrata, triangularis, vel qualiscunque; aut ipsum foramen non sit in medio fundo situm, vel etiam in latere vasis factum; idem erit Motus Cataractæ, scilicet æqualis Motui Prismaticis aquei sub foramine & altitudine  $AB$ , cujus velocitas par sit velocitati Aquæ effluentis. Nam eadem Aquæ moles, cum eadem velocitate atque in priori Hypothesi, tum per ipsum foramen, tum per singulas Cataractæ sectiones transibit.

3. Si vasis Diameter permagnam rationem obtineat ad Diametrum foraminis, negligi poterit altitudo  $AD$ , & vasis ipsius altitudo pro altitudine Cylindri, vel Prismatis aquei, usurpari.

Hactenus casum illum particularem, quo Aqua, Gravitatis vi, ex vase defluit, seorsim consideravimus. Id eo fecimus lubentius, tum quod illum fere solum adhibere soleant Mathematici, quoties agitur de Fluidorum impetu, tum quod Curvæ Hyperbolicæ supra expositam proprietatem, qua Cataractam Aquæ descendens format,



mat, non indignam conseamus contemplatione Geometrarum. Alioqui potuisset iste casus nullo negotio deduci ex Theoremate generali, quod proximo loco proponemus.

*Theorema III.*

*Fig. 12.* Aqua fluente per Canalem plenum quemcunque  $ABCD$  secundum lineam  $EF$ , cui sit perpendicularare utrumque Canalis orificium  $AB$  &  $CD$ , Motus Aquæ versus Orificium  $CD$ , sive Motus impimenti, quod in ipso orificio oppositum sistat Motum totius Aquæ, æquali est Motui Prismatis aquei sub qualibet Sectione Canalis  $CH$  & linea directionis, sive longitudine Canalis  $EF$ , quod moveatur eadem cum velocitate, qua Aqua fluit per istam Sectionem: sive æqualis Motui molis Aquæ, quæ dato quovis tempore effluit ex Canali, cujusque ea sit velocitas, qua percurratur eodem dato tempore spatium æquale longitudini Canalis.

*Cas. 1.* Sit linea directionis recta quævis  $EF$ .

Facile demonstratur pars prima eodem modo, quo Theorema primum. Est enim Factum ex quavis sectione Canalis  $CH$ , & Aquæ velocitate in ea Sectione, quantitas constans.

Pars secunda sequitur ex prima.

*Cas. 2. Fig. 13.* Si linea directionis  $ABCDE$ , ex pluribus rectis  $AB$ ,  $BC$ ,  $CD$ ,  $DE$ , ad sese invicem inclinatis sit composita, idem erit Aquæ Motus. Nam Motus Aquæ in toto Canali composito  $ABCDE$ , conficitur ex Motibus Aquæ in partibus Canalis  $AB$ ,  $BC$ ,  $CD$ ,  $DE$ , additis sibi invicem. Statuimus autem Aquam fluentem secundum rectam  $AB$ , mutata ista directione in aliam, qua feratur secundum rectam  $BC$ , nihil ex Motu perdere. Leges enim illas, quæ in motu corporum solidorum observantur, quoties eorundem directio

directio mutatur, fluida non sequuntur. Alioqui fluidum mutata directione in aliam priori perpendiculari, penitus silleretur, quod Experimentis neutiquam deprehenditur. Aqua porro ex Vasis foramine exiliens, sive deorsum, sive secundum Horizontis planum, sive rectâ sursum feratur, eandem obtinet velocitatem. Quod si aliquando vel ratiocinio subtiliori, vel Experimentis innotescet, aliquam Motus imminutionem ex mutata directione proficisci, erit ejusdem ratio habenda.

Si Curva fuerit linea directionis  $AB$ , referetur ad hunc Casum, quippe quæ ex pluribus rectulis confecta concipi queat. *Fig. 14.*

*Cas. 3. Fig. 15.* Si divisus fuerit Canalis  $AB$  in plures ramos  $BC$ ,  $BD$ ,  $BE$ , longitudine æquales, eadem ratione invenietur Aquæ Motus, usurpando pro linea directionis longitudinem  $ABD$ , compositam ex longitudine Canalis principis  $AB$ , & longitudine cujusvis rami  $BD$ . Perinde autem est, sive Aqua à Canali principe versus ramos, sive à ramis fluxerit versus principem Canalem. Quod si rami fuerint inæquales, inveniendus est Motus Aquæ in singulis ramis, adhibendo pro linea directionis longitudinem confectam ex longitudine cujusque rami, & longitudine principis Canalis.

Nullo negotio deducitur ex Casu secundo.

*Cas. 4. Fig. 16.* Si rami æquales, in quos distributus est Canalis  $AB$ , iterum in Canalem unicum  $FG$  colligantur, ad Motum Aquæ inveniendum adhibenda est pro linea directionis longitudo integra  $ABDFG$ , confecta ex longitudine principis Canalis  $AB$ , rami cujusvis  $BD$ , & Canalis recompositi  $FG$ . Si Rami sint inæquales, inveniendus est in singulis Aquæ Motus, & eorum Motuum Summa Motui Aquæ in Canali recomposito addendus. Sequitur ex Casu 2, & 3.

*Corol. 1.* Data longitudine Canalis, & qualibet Sectione ejusdem, erit Motus Aquæ in ratione velocitatis, qua

qua Aqua fluit per istam Sectionem.

2. Data quavis Sectione, & velocitate Aquæ Sectionem istam præterfluentis, erit Motus Aquæ ut longitudo Canalis.

3. Data Canalis longitudine, & velocitate Aquæ in quavis Sectione, erit Aquæ Motus in ratione illius Sectionis.

4. Dato Motu Aquæ, & aliqua Sectione, erit longitudo Canalis in ratione inversa velocitatis.

5. Dato Aquæ Motu, & longitudine Canalis, erit Sectio quævis reciprocè ut velocitas.

6. Data velocitate in qualibet Sectione, & Motu Aquæ, erit ista Sectio in ratione reciproca longitudinis.

7. Data longitudine Canalis, & mole Aquæ certo quovis tempore effluentis, erit Aquæ Motus reciprocè ut istud tempus.

8. Data Canalis longitudine, & tempore, erit Aquæ Motus ut moles effluens.

9. Dato tempore, & mole Aquæ effluentis, erit Aquæ Motus ut longitudo Canalis.

10. Dato Motu Aquæ, & longitudine Canalis, moles effluens est in ratione temporis.

11. Dato Aquæ Motu, & mole effluente, erit tempus ut longitudo Canalis.

12. Dato tempore, & Motu Aquæ, erit moles effluens reciproce ut longitudo Canalis.

13. Si binæ moles Aquæ motu contrario in directum occurrant & pares sint utrinque tum superficies quibus in se invicem impingant, tum velocitates quibus istæ superficies in adversum moveantur, fuerit autem altera moles Aquæ gutturæ uni æqualis, altera Aqua omnis Oceano contenta, vel etiam quantitas Aquæ infinita; fieri potest ut una ista guttula Aquam omnem Oceani, vel quantitatem Aquæ infinitam, non solum sustineat, sed

D d d d d

post

post occursum, eadem ac prius velocitate, ipsa in plagam eandem moveri pergat, eadem illam in partes contrarias repellat. Quod est mirabile Paradoxon in re Hydraulica.

14. Si certa moles Aquæ, per canalem ex tubis duobus cylindricis, Diametro inæqualibus, compositum, à tubo ampliore versus angustiores fluat, & motus Aquæ neque minuatür inter fluendum neque augeatur, simul ac prima pars Aquæ tubi minoris initium ingressa fuerit, statim tardius fluere incipiet, & continuato effluxu ex tubo latiore in angustiores, gradatim magis retardabitur Aqua in tubo angustiore usque dum tota in eum tubum pervenerit. Contrario modo res eveniet, fluente Aqua à tubo minore versus ampliorem. Quod est alterum Paradoxon in re Hydraulica. Ponitur autem Aqua ubique sibi cohærere

Oriuntur bina ista Corollaria ex Casu 1.

15 Ex Casu secundo datur Methodus æstimandi Motum Sanguinis in qualibet Arteria.

16. Utis quibuscunque Arteriis binis, æqualem Sanguinis molem transmittentibus, major est imperus Sanguinis in Arteria à Corde remotiore quam in propiore. Quod est Paradoxon notatu dignum in Oeconomia Animalis.

17. Ex Casu tertio oritur alterum Paradoxon in Oeconomia Animali, nempe majorem esse Sanguinis motum sive imperum, in Arteris omnibus Capillaribus simul sumptis, quam in ipsa Aorta. Item, major est in Capillaribus Venis, quam Arteriis.

18 Ex Casu quarto deducitur Methodus definiendi motum Sanguinis in quavis Vena.

19. Ex eodem deducitur tertium in Oeconomia Animali Paradoxon, nempe majorem esse sanguinis imperum in Vena quavis, quam in Arteria ei Venæ respondente,

dente, & proinde majorem esse in Vena Cava, quam in Aorta.

*Problema I.*

Invenire motum Aeris ex Pulmone effluentis.

Sit  $l$  = Longitudo rotius ductus aerei, ab Ore & Naribus ad extremos ramos Trachææ.

$q$  = Quantitas Aeris mediocri expiratione ex Pulmone emissæ.

$\mathcal{Q}$  = Aeris copia validissima expiratione expulsi.

$t$  = Tempus mediocri expirationis.

$T$  = Tempus expirationis fortissimæ.

Inde, per Theorema 3, *Cas.* 3, Motus Aeris ex Pulmone effluentis, in expiratione mediocri =  $\frac{q l}{t}$ .

$$\text{fortissima} = \frac{\mathcal{Q} l}{T}.$$

Hoc est, Motus Aeris ex Pulmone exeuntis æqualis est motui molis Aeris, quæ unica expiratione emittitur, cujus ea sit velocitas, qua percurratur tempore expirationis longitudo totius Canalis Aerei. *Q. E. I.*

Aeris quantitatem expiratione mediocri emissam Vir Clarissimus, *Alphonſus Borellus*, facto Experimento 18 circiter, vel 20 unciis cubicis definit. Est autem diversa, non solum in diversis Hominibus, sed etiam temporibus diversis, in Homine eodem. Ipse Experimentum in hunc modum institui.

Vesicæ madefactæ à parte inferiore pondus appendebam, & aprato eidem superius tubo vitreo Diametro circiter unciali, naribus obturatis Aerem vesicæ leniter inspirabam, per spatium trium minorum secundorum, pondere interim in manâ quiescente. Postea Vesicam cum Aere incluso & pondere appento, sub Aquam in vase cylindrico contentam, demergebam, notata diligenter altitudine, ad quam Aqua attollebatur.

Deinde, Aere ex vesica expulso iterum eandem cum pondere in Aquam immittebam. Quod cum esset factum, facile inventebatur Aquæ moles quæ vasi infusa altitudinem prius notatam conficeret. Experimento decies repetito, & additis tibi-invicem quantitatibus singulis inventis, earum decima sive media moles Aquæ vasi infusa, reperiatur 35 unciis cubicis æqualis. Quæ moles est Aeris vesica contentæ: & adjecta circiter parte duodecima, seu 3 unciis cubicis, ob Aeris condensationem à frigore Aquæ factam, cum tempestas fuerit hyemalis, efficiuntur 38 uncia cubica. Præterea addendum est tantillum, tum propter Aquæ pressionem in vesicam, tum ob Vaporem qui cum halitu emittitur in humorem coactum; quod fiat necesse est ex frigore Aquæ, & vesicæ madidæ contactu. Æstimavi igitur Aeris copiam, leni expiratione emissam tempore trium minutorum secundorum, numero rotundo 40 unciarum cubicarum.

In expiratione validissima expirabam uncias cubicas 125, tempore minuti secundi unius.

Hujusmodi autem expiratione, cum vehementi Pulmonis contentione ad strangulatum fere continuata, 220 uncias cubicas ex Pectore emittebam. Unde patet, ut id obiter moneam, multo plus Aeris in Pectore superesse, quam unica expiratione mediocri emitti.

Si ergo ponatur  $l = 2$  pedes

$$q = 40 \text{ uncia cubica}$$

$$\mathcal{Q} = 125 \text{ uncia cubica}$$

$$t = 3''$$

$$T = 1''$$

Aeris Gravitās Specifica ad Gravitatem Aquæ, ut  $\pi$  ad 1000.

Pes Aquæ cubicus = 1000 unc. *Avoird.*

Erit Motus mediocris Aeris Pulmone exeuntis æqualis motui ponderis Scrupulorum 4 & Granorum 9, quod percurrat unciam unam minuto secundo; vel  
motui

motui ponderis Grani  $1 \frac{1}{4}$ , quod eodem tempore conficiat longitudinem 5 pedum & 7 unciarum. Quæ est velocitas Aeris per Laryngem effluentis, posita Laryngis Sectione  $= \frac{1}{4}$  uncix quadratæ.

Motus maximus Aeris Pectore expulsi æquatur motui ponderis uncix  $1 \frac{3}{4}$  circiter, percurrentis unciam unam minuto secundo; sive motui ponderis grani  $1 \frac{1}{4}$  percurrentis eodem tempore 52 pedes. Quæ est velocitas Aeris in fortissima expiratione per Laryngem erumpentis.

*Corol. 1.* Data Aeris copia & longitudine Canalis aerei, motus Aeris est in ratione inversa temporis expirandi.

2. Data mole Aeris & tempore, erit motus in ratione directa longitudinis.

3. Data longitudine & tempore, motus est ut Aeris copia.

4. Dato motu & Aeris copia, erit longitudo in ratione directa temporis.

5. Dato motu & longitudine, erit Aeris moles directe ut tempus.

6. Dato motu & tempore, erit Aeris moles reciproce ut longitudo Canalis Aerei.

7. Motus Aeris est in ratione composita ex ratione quadruplicata Diametri cujuscvis homologæ ipsius Animalis, & ratione inversa temporis expirandi; vel in ratione composita ex ratione ponderis totius Animalis, ratione ejusdem ponderis subtriplicata, & ratione temporis reciproca.

Nam pondus Animalis. Diametri cujuscvis homologæ Cubus & moles Aeris expulsi sunt in eadem ratione. Ponitur autem Corpora Animalium Machinas esse similiter factas

*Achilium* Longitudinem hic usurpatam, vel ipsam esse concipies Canalis aerei longitudinem, si Rami omnes  
Tra-

Trachææ longitudine æquales ponantur : vel mediam inter longitudes diversas, si Rami sint inæquales.

*Problema II.*

Determinare impetum, sive impressionem quam excipit interna Pulmonum superficies ab Aere expirando.

Cum actioni æqualis & contraria sit reactio ; necesse est, ut, quanto motu urgetur ab interna Pulmonum superficie Aer expirandus, tanto vicilim ab Aere repellatur superficies Pulmonum.

Unde, per Problema superius, impetus dictus in expiratione mediocri  $= \frac{q l}{t}$

$$\text{fortissima} = \frac{2l}{T}. \quad Q.E.I.$$

Hinc positis iisdem quæ in superiore ponuntur, impetus mediocris Aeris in Pulmones æquales est motui ponderis drachmæ circiter  $1 \frac{1}{2}$ , quod minuti secundi spatium percurrat unciam unam ; vel motui ponderis 19 librarum, coefficientis eodem tempore  $\frac{1}{164}$  uncia, quæ est velocitas Aeris in contactu superficiei Pulmonis internæ. Ponimus autem cum Viro Doctissimo *Jacobo Keilio* superficiem Pulmonis internam 21900 circiter unciis quadratis æqualem.

Impetus vero maximus Aeris in Pulmones æquatur motui ponderis uncia circiter  $1 \frac{3}{4}$  moti unciam unam minuto secundo ; vel motui ponderis 19 librarum, quod partem  $\frac{1}{175}$  uncia conficiat eodem tempore. Quæ est Aeris velocitas ad superficiem Pulmonis in expiratione vehementi.

*Corol. I.* Sequuntur ex hac Propositione Corollaria precedenti subjuncta.

2. Imperus mediocris incumbens in partem superficiei Pulmonis, quæ sit ipsi Laryngis Sectioni æqualis, est  
motus



motus ponderis  $\frac{1}{12}$  grani, conficientis uncix spatium minuto secundo; vel motus grani  $1 \frac{1}{2}$  quod eodem tempore percurrat uncix partem  $\frac{1}{164}$ . Impetus autem maximus in parem superficiem est motus ponderis  $\frac{1}{191}$  partis grani quod unciam unam; vel motus ponderis grani  $1 \frac{1}{2}$  quod  $\frac{1}{13}$  uncix singulis minutis secundis conficiat.

3. Impetus Aeris in mediocris expiratione in Pulmones impressus, æquatur motui Columnæ aqueæ percurrentis unciam unam minuto secundo, cujus Columnæ basis est ipsa Pulmonum superficies interna altitudo autem est  $\frac{1}{38}$  uncix. Etque Columnæ altitudo pars  $\frac{1}{730}$  uncix, in expiratione omnium vehementissima.

4. Impetus incumbens in superficiem parem circulo maximo Globuli sanguinei, in leni expiratione, est pars  $\frac{1}{12}$  ponderis Globuli Sanguinei; in expiratione vehementi  $\frac{1}{3}$  ejusdem ponderis, motu unciam unam minuto secundo. Qua autem ratione Diametros Globulorum Sanguinis dimensus sim, cum usui esse queat ad aliorum Objectorum minimorum magnitudines definiendas, libet obiter exponere. Capillum tenue, & satis longum, aciculæ puries circumvolvi, ut omnes convolutiones sese invicem accurate contingerent, quod admotum subinde Microscopium luculenter ostendebat. Deinde cum intercapedinem inter extremas utrinque circumvolutiones Citrino cepissem, eandem Scalæ, quam vocant. Diagonali applicabam, spatiumque in Scala repertum per convolutionum numerum dividebam. Unde inventa est unius convolutionis latitudo, sive ipsa Capilli Diameter. Postea Capillum eundem, in Segmenta minutula divisum, plano Microscopii, cui sanguinis parum ita erat illitum ut Globuli conspicerentur distincti, superinspergebam. Ea cum Microscopio contuerer, reperiēbam aliquibus in locis Capilli Segmenta ita commode disposita, ut numerare liceret, quot Globuli Diametro Segmenti opponerentur. Erant autem Segmenta Diametro inæqualia, quod

quod Capillus tenuior versus extremum fuerit, quam propius à Radice, adeo ut jam 7, vel 8, jam 12, 13ve Globuli transversæ Sectioni Capilli responderent. Utroque autem Experimento sæpius iterato, æstimavi tandem mediam Capilli Diametrum parte  $\frac{1}{324}$  uncix, & Diametrum Globuli Sanguinei parte decima Diametri Capilli, sive parte  $\frac{1}{324}$  uncix

5. Impetus, quem patitur interna Pulmonum superficies ab Aere expirando, minor est Motu lenissimi roris è Cælo decidentis

*Scholium* Neglecta est in solutione Problematum duorum præcedentium impedimenti consideratio, quod Aeri ex Pulmone egredienti objicitur ex afflictu laterum Arteriæ Trachææ, ejusque ramorum: cum id perparvum sit, neque ullo experimento satis accurate æstimari posse videatur. Nec fuimus admodum solliciti de rationibus numerorum exquisitè servandis, cum id unum nobis propositum fuerit, ut methodum exponeremus æstimandi, aliquanto certius quam videtur antehac factum, vires eas, quibus agit Aer inter expirandum in vasa sanguinea superficiem Pulmonis internam perreptantia. Unde dignosci potest, utrum pares sint hæ vires effectis istis producendis, quæ iisdem à Doctissimis quibusdam Scrip- toribus Medicis tribuuntur. Quod liberum esto Lectoris Scientia Mechanica & Anatomica instructi Judicium.

### *Problema III.*

Definire impetum Sanguinis in Vena Cava prope dextram Auriculam Cordis; sive motum Sanguinis per omnes Arterias & Venas fluentis, præter Pulmonares.

Sic  $q$  = Quantitas Sanguinis una Cordis Systole in Aor- tam projecti.

$l$  = Longitudo media ductus integri Arterio-Venosi, ratione habita ramorum longiorum & breviorum

$t$  =

$t$  = Temporis spatium inter binos Pulsus interceptum.

Inde, per Theorema 3. Cas. 4. impetus quæsitus  
 $= \frac{q l}{t}$ .

Hoc est, Impetus Sanguinis in Vena Cava æquatur motui molis Sanguinæ, quæ una Systole in Aortam projicitur, cujus ea sit velocitas, quæ percurri queat integra Arteriarum & Venarum longitudo, temporis spatium inter binos Pulsus intercepto. *Q. E. I.*

Si in Corpore Humano ponantur

$q = 2$  uncia *Avoird.*

$l = 6$  pedes

$t = \frac{3''}{4}$ .

Erit impetus Sanguinis in Vena Cava æqualis motui ponderis 12 librarum, quod uncia unius longitudinem conficiat singulis minutis secundis; seu motui ponderis 2 librarum, quod pari temporis spatio percurrat pedem  $\frac{1}{2}$ . Quæ est fere Sanguinis velocitas in Cava fluentis. Ponimus autem, ex dimensione Viri Doctissimi supra dicti, Cavæ Sectionem dodrantem esse uncia quadratæ.

*Corol.* Oriuntur ex hoc Problemate mutatis mutandis omnia Problematis primi Corollaria.

#### *Problema IV.*

Determinare motum absolutum Sanguinis in Vena Cava; sive motum Sanguinis, per omnes Arterias & Venas fluentis ræ æter Pulmonales, sublata Vasorum resistentia.

Sit velocitas Sanguinis Naturalis, ad eam velocitatem qua Sanguis flucret, dempra omni resistentia, ut 1 ad  $\infty$ . Cumque per *Corol.* superioris Problematis, & *Corol. I.*

Eeeee

*Probl.*

*Probl. 1.* Motus Sanguinis sit in ratione velocitatis, erit inde motus quæsitus  $= \frac{x q l}{t}$ . *Q. E. I.*

Quod si proportio per Experimentum à Viro Clarissimo supra laudato institutum inventa, ut veræ propinqua, admittatur, erit  $x = 2.5$ .

Unde, positis iisdem quæ in superiore ponuntur, motus absortus Sanguinis in Vena Cava æquatur motui ponderis 30 librarum, quod minuto secundo longitudinem uncialem percurrat; sive motui ponderis 2 librarum percurrentis eodem tempore pedem  $1 \frac{1}{4}$ . Quæ fere velocitate Sanguis, omni resistantia liber, per Cavam deferretur.

#### *Problema V.*

Motum Sanguinis invenire in Vena Pulmonali prope sinistram Cordis Auriculam; sive motum totius Sanguinis per Pulmonem fluentis.

Præter notulas in *Probl. 3.* usurpatas, sit  $\lambda =$  Canalis Arterio-Venosi Pulmonici media longitudo.

Unde, per *Theor. 3. Cas. 4.* invenitur motus quæsitus  $= \frac{q \lambda}{t}$ .

Hoc est, motus Sanguinis per Pulmonem fluentis æqualis est motui molis Sanguinæ, quæ una Systole in Arteriam Pulmonalem projicitur, obtinentis eam velocitatem, qua percurratur longitudo Arteriarum ac Venarum Pulmonalium, tempore inter duos Pulsus intercepto. *Q. E. I.*

Si ponatur in Corpore Humano  $\lambda = 1 \frac{1}{4}$  pes.

Erit motus Sanguinis in Pulmone æqualis motui ponderis 3 librarum, percurrentis unciale spatium minuto secundo.

*Problema*

*Problema VI.*

Definire momentum Sanguinis absolum in Vena Pulmonali.

Eodem argumento, quod in *Probl* 4. usurpatum est, invenitur motus quæsitus  $= 2.5 \times \frac{q\lambda}{t}$ . *Q. E. I.*

Positis vero iisdem quæ supra ponuntur, motus absolum Sanguinis Pulmonem præterfluentis æquatur motui ponderis 7  $\frac{1}{2}$  librarum, quod singulis minutis secundis uncie unius spatium percurrat.

*Scholium.* Experimento *Keiliano* definita est proportio, quam obtinet Sanguinis per Aortam ejusque ramos fluentis velocitas naturalis, ad eam velocitatem qua Sanguis per eosdem flueret, sublata resistantia Arteriarum & Sanguinis præcedentis. Eam nos proportionem ad Sanguinem per Arteriam Pulmonalem fluentem transfulimus. Quia vel sublata vel imminuta secundum quamvis rationem resistantia, quæ Sanguini per utramque Arteriam fluenti objicitur, necessario Sanguis pariter acceleratur in utraque Arteria. Id enim nisi fiat, bini Cordis Ventriculi aut eodem tempore non contrahentur, aut eandem Sanguinis quantitatem non ejicient. Quorum utrumvis, absque summa totius Machinæ perturbatione & discrimine, fieri omnino non potest.

*Corol.* Ad tria Problemata præcedentia.

Sequuntur hinc Corollaria Problemati quinto subjuncta, mutatis mutandis.

*Scholium* ad quatuor Problemata superiora.

Notandum Sanguinis velocitatem, tum per Pulmonem, tum per reliquum Corpus fluentis, cum reipsa æquabilis non sit, hic tamen talem fingi, ut motus Sanguinis medius inveniat.

*Scholium generale.*

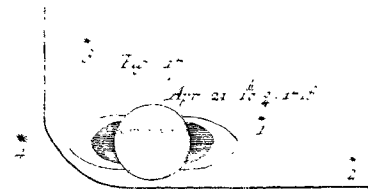
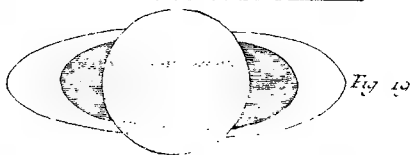
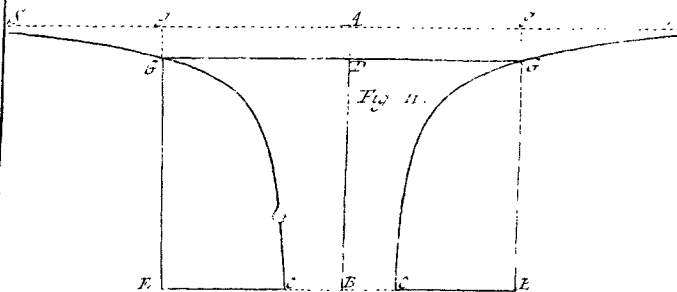
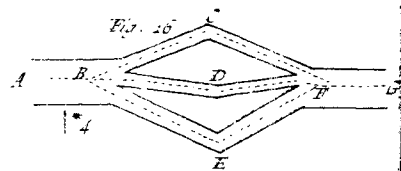
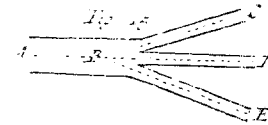
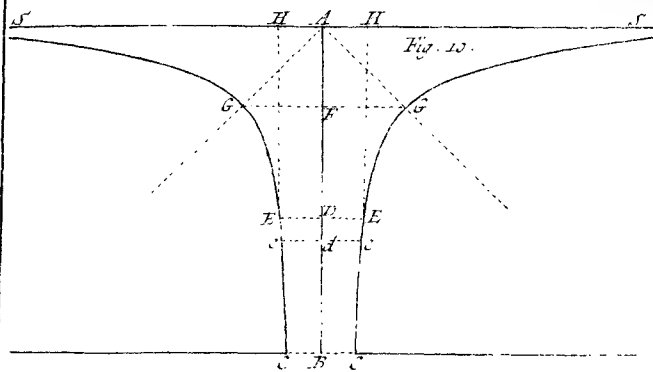
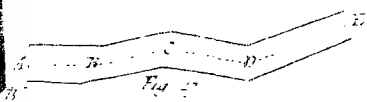
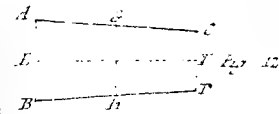
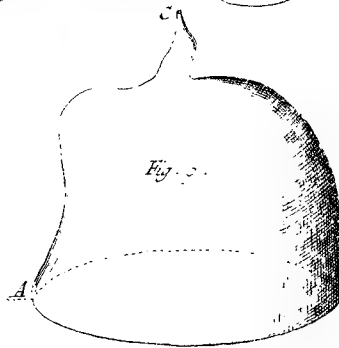
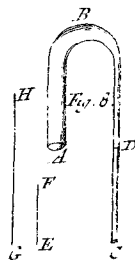
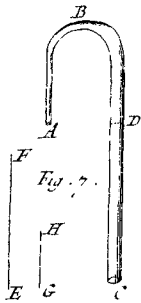
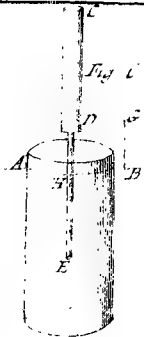
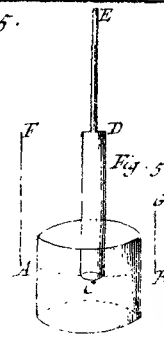
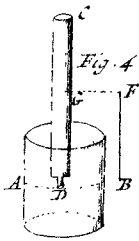
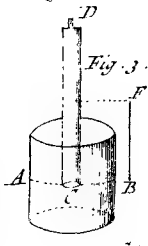
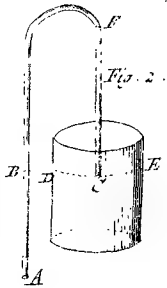
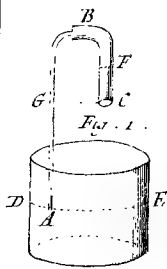
Si cui numeri minus accurati videantur, qui sparsim Characteribus speciosis apponuntur, poterit ille facili opera, inventis per experimenta numeris qui propius ad verum accedant, motuum exempla supra posita. vel Propositionum ipsarum vel Corollariorum ope, corrigere. Ignoscat autem nobis Lector ingenuus, si per viam incedentibus nullis præcedentium vestigiis tritam, adeoque Erroribus in omnes partes opportunam, Humani aliquid forte acciderit.

*Damus hanc veniam, petimusque vicissim.*

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IV. *An Account of the Sinking of three Oaks into the Ground, at Manington in the County of Norfolk. Communicated by Peter Le Neve, Esq; Norroy King at Arms, and Fellow of the Royal Society.*

ON Tuesday July the 23<sup>d</sup>, of the last Year. 1717, in the Grounds, and near the Seat of Sir Charles Potts, Baronet, in the County of Norfolk, and Parish of Manington, (which lies about mid-way between the Market Towns of Holt and Aylsham, and about seven Miles from the Coast near Cromer) in the day time, to the great astonishment of those that were present; first, one single Oak. with the Roots and Ground about it, was seen to subside and sink into the Earth and not long after, at about 40 Yards distance, two other Oaks that were contiguous, sunk after the same manner, into a much larger Pit; being about 33 Foot Diameter, whereas the former is not full 8. These, as they sunk, fell a-crois, so that obstructing each other, they



the Roots of one of them reaches the Bottom, whereas the first stands Perpendicular.

When the first Tree sunk, it was observed, that the Water boy'd up in the Hole; but upon the making of the greater Pit, that Water drain'd off into it, from the former, which now continues dry. The depth thereof to the firm Bottom is nine Foot three Inches; and the Tree that stands upright in it, is 3 Foot 8 Inches in Girt, and its Trunk about 18 Foot long, half of which is now within the Pit. In the Bottom of the greater Pit, there is a Pool of Water about 8 Foot Diameter; whose Surface is 11 Foot 3 Inches below the Ground, and the Trees that are in this Pit, are much of the same length with the other, but somewhat smaller, the one being in Girt 3 Foot 5 Inches, the other but two Foot 9 Inches

The Soil on which these Trees grew, is Gravelly; but the Bottom is a Quick-sand over a Clay, upon which there are Springs, which feed large Ponds adjoining to Sir *Charles Potts's* House, at about a quarter of a Mile from these Holes.

The Nature of the Soil seems to afford us a reasonable conjecture at the Cause of this odd accident, which some perhaps may be apt to reckon as a Prodigy. The Springs running over the Clay at the bottom of a Bed of very minute Sand, such as your Quicklands usually are, may reasonably be supposed in many Ages to have wash'd away the Sand, and to have thereby excavated a kind of Subterraneous Lake, over which these Trees grew: And the force of the Winds, on their Leaves and Branches, agitating their Roots, may well have loosened the Sand under them, and occasioned it to fall in, more frequently than elsewhere: whereby in length of time the thin Bed of Gravel being only left, it might become unable to support its own weight and  
that



that of the Trees it bore. That this is not a bare conjecture, may appear from the boiling up of the Water at first in the lesser Hole, and its standing in the bigger and lower. And if it shall be found that it was a very windy day whereon this accident happen'd, it will much add to the probability of this Solution.

An accident not unlike this lately happened in *Fleet-street, London* by the defect of the arched Roof of a very deep Common-sewer. The Earth gradually falling into the Sewer, was carried away by it, so as not to obstruct the Water; and the continual tremour of the Ground, occasioned by the constant passing of Carts and Coaches, by degrees shook down the earth, so as to leave a very great Cavern, the Top whereof at length grew so very thin, that one day a weighty Cart having just past it, a great space of the Pavement sunk in, in the middle of the Street, not without hazard to a Coach then driving by.

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V *A Rectification of the Motions of the five Satellites of Saturn; with some accurate Observations of them, made and Communicated by the Reverend Mr. James Pound.* R.S. Soc.

IT is now above thirty Years since that great Astronomer Mr. *Cassini* communicated to the World his discovery of two new Satellites of *Saturn*, which made their number Five; and the account he gave of them to the *Royal Society*, (of which he was a Member) is to be seen in N<sup>o</sup> 187, of these Transactions. Much about the same time the excellent M. *Christian Huygens* of *Zurichem*, made the Society a present of the Glasses or a  
Telescope

Telescope of 125 Foot length, with the *Apparatus* for using them without a Tube; by help whereof we might have satisfied our selves of the reality of these Discoveries. But those here that first tried to make use of this Glass, finding for want of Practice, some difficulties in the Management thereof, were the occasion of its being laid aside for some time. Afterwards it was designed for making perpendicular Observations of the fixt Stars passing by our Zenith, to try if the Parallax of the *Earth's* annual Orb might not be made sensible in so great a Radius, according to what *Dr. Hook* had long since proposed: but in this we miscarried also, for want of a place of sufficient height and firmness, whereon to fix the Object Glass, so that it lay by neglected for many Years.

In the mean time we could not but remark a great reserve in the *French* Astronomers, in relation to these Satellites, of which they have given us in their Yearly *Memoirs* no Observations till very lately, nor have they seemed willing to shew them in their Glasses to such as requested it: so that it might possibly occasion in some Persons a suspicion of the reality of this Discovery: And the Reverend Mr. *William Derham* having borrowed of the Society their long Glass, could not thereby assure himself that the small Stars he sometimes found about *Saturn*, were really his Satellites, their situation not agreeing with their places derived from the Tables of their Motions exhibited in N<sup>o</sup>. 187. of *Phil. Transact.* besides that he wanted a sufficient height to raise the Object Glass, so as to view *Saturn* to advantage, above the Vapour of the Horizon. But in the *Memoirs* for 1714, published but about a Year since, M. *Cassini*, the worthy Successor of his great Father, has given us some Observations which clear up the Point, and by shewing the errors of those first Tables, has enabled us to be assured,

that.

that we have seen the whole *Satellitum* of *Saturn* ourselves.

The Substance of these Observations is as follows.

*Anno 1714 Maii 6. St. N.* about Mid-night, *Saturn* being then Stationary in  $\varpi 4^{\circ}. 27'$ , the Fifth and outermost Satellite was in its superiour Conjunction with the Planet, and at the same time, the Earth was nearly in the Plain of this Satellit's Orbit, so that it appeared to pass very near the Center of *Saturn*: From hence and from some other preceeding Observations, Mr. *Cassini* concludes that the Nodes of this Satellit's Orb are in 4 degrees of  $\varpi$  and  $\chi$ , and that its Inclination to the Ecliptick is not much more than half that of the other Satellites. Hence it should follow that the Elliptics it describes by its apparent motion about *Saturn*, when in  $\pi$  and  $\tau$  are much flatter and nearer to his Body, than those of the other four, which he allows to move in the plain of the *Ring*, and to have their Nodes in  $21^{\text{st}}$  of  $\varpi$  and  $\chi$ , with an Inclination to the Ecliptick of 31 degrees. To confirm this discovery, he produces another Observation of his Fathers, near Thirty Years before, viz. that, *Anno 1685, Maii 31. St. N.* about Noon, the same Satellite was observed in superiour conjunction with *Saturn*, with less than one Diameter of the *Ring* North latitude, *Saturn* being then in  $\varpi 11^{\circ}. 48'$ . So that the Satellite wanted but  $7^{\circ}. 21'$  of compleating 134 Revolutions, in the Interval of time between them. From these *Data* it was easy to settle the Theory of this Satellite.

As to the *Fourth* or the *Hugenian* Satellite; in the *Memoirs* for 1715. but just now come to hand, we find a very curious Observation of it, and the first of its kind, viz. that *Mart. 25. S. N.* about 11<sup>h</sup> P. M. this fourth Satellite, then in *Apogeo*, did immerge behind the Body of  
*Saturn*

*turn.* With this Emendation the place of this Satellite may for the future be computed with a sufficient exactness.

The Third Satellite, by an original mistake in the Letters in N<sup>o</sup>. 187, is all wrong; its daily Motion being there printed 2'. 18°. 41'. 50" instead of 2'. 15°. 41'. 50"; as may be perceived by the Period thereof being determined, in the aforesaid *Memoirs* of 1714, to be 4<sup>d</sup>. 12<sup>h</sup>. 25'. 12". that is, that it makes 400 Revolutions in 1807 days. This Satellite was observed by Mr. *Cassini*, April 4<sup>o</sup>. St. N. 10<sup>b</sup>. P. M. to have newly past its inferior conjunction with *Saturn*. and a perpendicular from it fell on the extremity of the western *Anse*. so that at about 5<sup>b</sup>. P. M. it was with the center of the Planet then in  $\pi$ . 5°. 23'. and consequently in  $\times$  5°. 23'. But *ineunte anno Gregoriano* 1686, the *Epoche* thereof was  $\pi$  9°. 39'. So that from the Noon of the last of December 1685, to April 4<sup>o</sup>. 6<sup>b</sup>. 18'. anno 1714, that is, in 10320 Days 6<sup>b</sup>. 18', there have been made 2284½ Revolutions of this Satellite to the Equinoctial; from which *Data*, the Tables of its Motion are readily derivable.

The Radix of the penintime or second Satellite, according to the aforesaid Letter, *ineunte anno Greg.* 1686. was in  $\pi$  9°. 10'. But by the Observations of Mr. *Cassini* made the Nights before and after, this Satellite was in its superior Conjunction anno 1714. April 4<sup>d</sup>. 21' ½. St. N. that is, in  $\pi$  5°. 21', where *Saturn* then was: So that April 4<sup>d</sup>. 22<sup>b</sup>. 12', an entire Number of Revolutions were performed since the *Epoche* of 1686, that is, in 10320 Days 22<sup>b</sup>. 12': which Number can be no other than 37 1, according to the Period thereof given in this *Memoire*, viz. 2<sup>d</sup>. 17<sup>b</sup>. 41'. 22".

Lastly the innermost or first Satellite, at the same time, viz. 1714, April 4<sup>o</sup>. 21<sup>b</sup>. 30'. St. N. was in its inferior

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feriour conjunction *proxime*, and consequently in  $\times 5^{\circ} 21'$ . But the *Epoche* thereof for 1686, is  $\nu. 24^{\circ} 50'$ . Which place the Satellite had past  $40^{\circ} 31'$  at the time of the Observation. This Arch it moves in  $5^h. 6'$ : Wherefore from the time of the *Epoche* to April 4<sup>d</sup>.  $16^h. 24'$ , 1714, or in 10320 Days  $16^h. 24'$ . the Satellite has performed 5467 Revolutions, its Period being determind to be 1 Day, 21 hours,  $18'. 27''$ , in this *Memoire*.

Having by the help of these late Observations corrected the motions of the Satellites which it was not possible for their first Discoverer to settle truly, in the short interval before 1687; and having fixed their *Epoches* for the present Year, we were enabled to know where to expect them with more certainty, and to distinguish them one from another, and from the small fixt Stars appearing with them. And the Reverend Mr. *James Pound*, (whose indefatigable Industry is no way inferiour to his incomparable Skill in Astronomical matters) having, by means of his Steeple of *Wansted*, provided a *Gnomon* high enough for the purpose, and having fitted a very commodious *Apparatus* for using the Society's aforesaid long Telescope, soon discovered by it all these five Satellites; and lately communicated to them the following very curious Observations.

1718. April 21<sup>d</sup>.  $10^h. 40'$ . The third and fourth Satellites of *Saturn* were in *Apogæo*, a little past their Conjunction with *Saturn*: A perpendicular from the fourth to the Transverse *Axis* of the Ring (or Line of the *Anse*) fell a little without the Eastern *Ansa*; and a Line through the fourth and third touch'd the Eastern Limb of *Saturn*. *Fig. 17.*

The first was Northward of the Line of the *Anse* (and therefore in the *Apogæon* Semicircle also) distant from the said Line about as far as the end of the Conjugate *Axis* of the Ring was from the Center of *h*, viz. nearly

nearly  $\frac{1}{4}$  of *Saturn's* Semidiameter; and it was about a Semidiameter of the Ring from the Western *Ansa*.

The second was a very little Southward of the Line of the *Ansa* (and therefore in the *Perigæon* Semicircle) above a Semidiameter of the Ring (or about the Semidiameter of the Ring  $+$  the Semidiam. of  $\eta$ ) from the Western *Ansa*. And the Third, First and Second were in a strait Line.

At  $10^h. 50'$ . A Perpendicular from the  $3d$  to the Line of the *Ansa* fell almost on the middle of the bright part of the Eastern *Ansa*, but somewhat nearer the Center than the said middle.

*April 22<sup>d</sup>. 11<sup>h</sup>. 5'*. The four innermost Satellites were all Eastward of  $\eta$ . The  $2d$  and  $4th$  in the *Apogæon*, and the  $1st$  and  $3d$  in the *Perigæon* Semicircle. A Line through the  $2d$  and  $4th$  touched the *South-East* Limb of  $\eta$ . A Line passing through the  $3d$  and the end of the Conjugate *Axis* of the Ring, was parallel to the Line of the *Ansa*.

At  $11^h. 10'$  A Perpendicular from the first to the Line of the *Ansa* fell on the Eastern Extremity of the Ring. *Fig. 18.*

These Distances and Directions were taken only by Estimation, and not by any actual Measurement.

The fifth (or outermost) Satellite being at this time near its greatest Elongation Eastward, among several very small Telescopic Stars, he could not determine its Position. But by observing the Motion of this some other Nights before, he was now fully satisfied, from the Motions rectified as above, that there are five Satellites of *Saturn*, as Mr. *Cassini* had long since asserted.

In the bright part of each *Ansa* was a darkish Ellipse nearer to the out side than the in-side of the Ring. as if it was composed of two Rings near to one another.

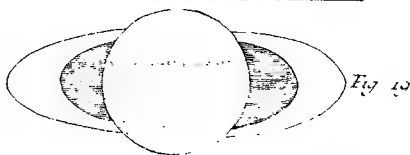
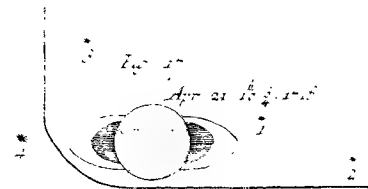
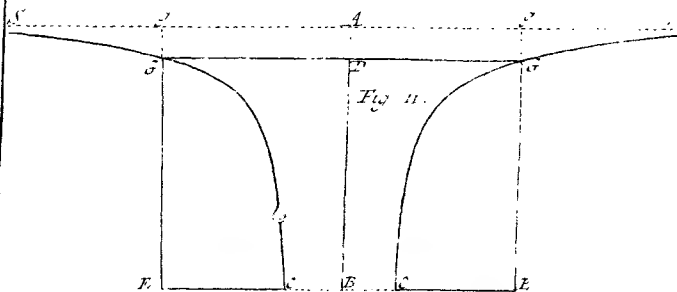
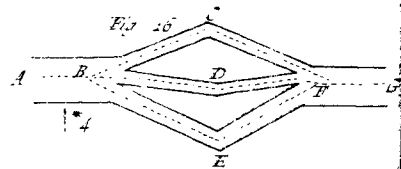
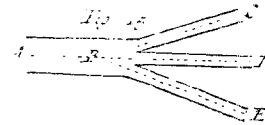
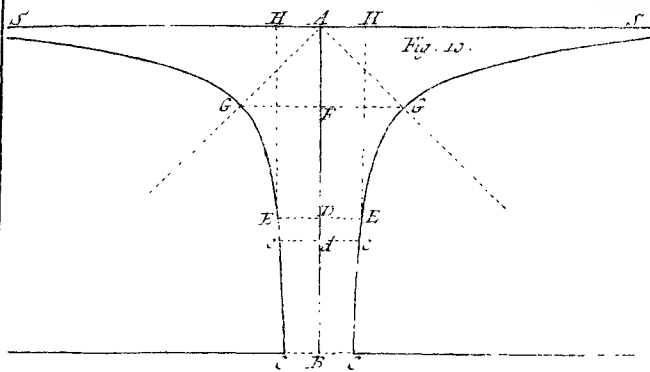
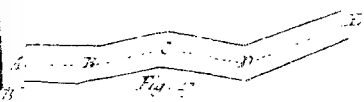
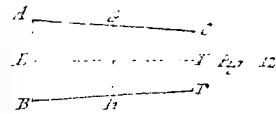
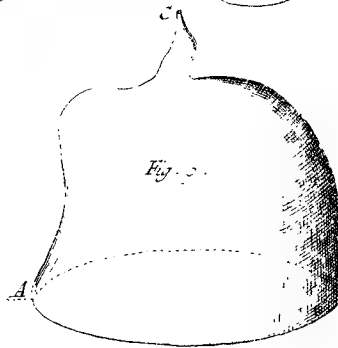
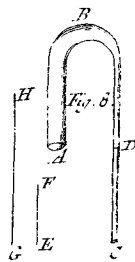
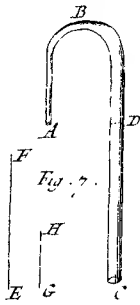
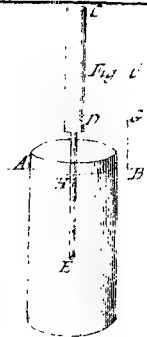
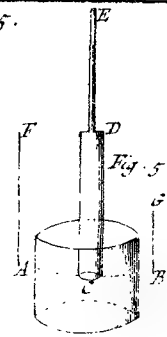
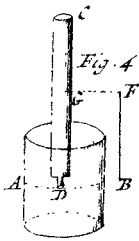
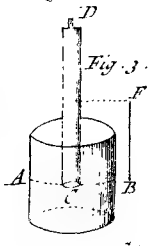
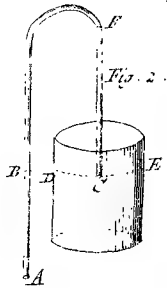
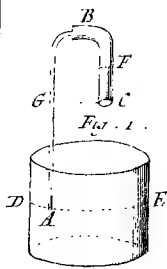
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On the Body of *h*, beside the Ring on the *South-side*, there appeared on the *North-side* a Zone not so far from the Center as the Ring, and not much unlike the smallest of *Jupiter's* Belts. These appearances were first taken notice of by Mr. *Cassini*, as may be seen in *Phil. Trans.* N<sup>o</sup>. 128 pag 690. *Vide Fig. 12.*

We shall in our next give the Publick Tables of these Motions, corrected from the aforesaid Observations, instead of those in N<sup>o</sup>. 187. But it is not to be expected that these Satellites, exceedingly minute in themselves, and so faintly illuminated, should appear when the Air is but ordinarily Serene, they requiring not only the *Medium* to be *summo modo* defecate and impid but withal in perfect Darkness. For which reasons it may well be understood why the Gentlemen of the *Parisian* Observatory may have sometimes made a difficulty to undertake to shew them upon demand.

# F I N I S.

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# PHILOSOPHICAL TRANSACTIONS.

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For the Months of *May*, and *June*, 1718.

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I. *Tabula*

I. *Tabula Motuum quinque Satellitum Saturni ad fidem nuperarum Observationum correctæ, Cæloque conformes redditæ.*

**C**irca finem Anni 1686. D. Jo. Dom. Cassini, Reg. Soc. Sodalis, & in Astronomicis nemini secundus, cum Societate nostrâ inventa sua de motibus quinque Satellitum *Saturni* communicavit, Epochasque singulorum ad annum ineuntem 1686. eorumque motus diurnos in Epistola. N° 187. harum *Transact.* editâ exhibuit: E quibus datis motuum Tabulas concinnavimus, dictæque Epistolæ subjunctas una edidimus. Cum vero deinde per triginta fere annos nullas omnino Observationes eorum tradiderint, qui soli poterant, Astronomi *Galli*; cumque aliunde, ob intervallum temporis nimis breve, non nisi laxè periodos Satellitum, præsertim interiorum, definire potuerit præclarissimus Inventor; non prius dictarum Tabularum defectus corrigere datum est, quam in nuperis Actis Academiæ Regiæ *Parisiensis* Physicis & Mathematicis, observata ea, quæ sub finem præcedentis *Transact.* N° 355. protulimus, prodire.

Horum vero ope facta aliquali Motuum castigatione, tum demum Telescopio *Hugeniano* omne Saturni Satellitum ipsi agnovimus; adhibitisque accuratis Rev. D. Jac. Poundi observationibus, Tabulas subsequentes cælo satis consonas obtinuimus. Addendo sc. motui annuo *Interioris*,  $2^{\circ} 8' 9''$ ; *Penultimi* vero  $3^{\circ} 25'$  retentis Epochis D. Cassini ad Annum 1686. Augendo etiam motum annum *Extimi* 9 min. sublatis vero 16 grad. ab *Epocha*, quæ in Epistola dicta N° 187. perperam scribitur  $\propto 16^{\circ} 19'$ , pro  $\propto 0^{\circ} 16'$ . *Hugenianum* 6' annuatim tardiore invenimus. *Tertii* autem Tabellas, ob motum diurnum falsò in Epistola illa traditum, de integro recudere necesse habuimus, retenta saltem *Epocha*.

*Tabula*

*Tabula Mediorum Motuum Intimi Satellitis  
Saturni à Cassino detecti Anno 1686.*

<i>Annis Christi incunt</i>	<i>Epoche</i>	<i>Annis</i>	<i>Mot. Med.</i>	<i>Diebus</i>	<i>Mot. Med.</i>	<i>H M</i>	<i>Mot. Med.</i>	<i>Motus Medi.</i>
<i>s . o .</i>	<i>s . o .</i>	<i>s . o .</i>	<i>s . o .</i>	<i>s . o .</i>	<i>s . o .</i>	<i>S. x. o .</i>	<i>Min.</i>	<i>o .</i>
1681	8 48	1	4 443	1	6 10 42	10 7 57	34	6
1686	13 4	2	8 9 25	2	0 21 24	20 15 53	324	14
1701	6 34	3	0 14 8	3	7 2 6	30 23 50	334	22
1714	9 57	4	10 29 33	4	1 12 47	40 31 47	344	30
1715	14 39	5	3 4 16	5	7 23 29	50 39 44	354	38
1716	19 22	6	7 8 59	6	2 4 11	60 47 40	364	46
1717	4 47	7	11 13 42	7	8 14 53	70 55 37	374	54
1718	9 30	8	9 29 6	8	2 25 35	81 3 34	385	2
1719	14 13	9	2 3 49	9	9 6 17	91 11 31	395	10
1720	18 55	10	6 8 32	10	3 16 59	101 19 28	405	18
<i>Menf Anni Com.</i>	<i>Mot. Med.</i>	<i>11</i>	<i>10 13 15</i>	<i>11</i>	<i>9 27 41</i>	<i>111 27 24</i>	<i>415</i>	<i>26</i>
	<i>s . o .</i>	<i>12</i>	<i>8 28 40</i>	<i>12</i>	<i>4 8 22</i>	<i>121 35 21</i>	<i>425</i>	<i>34</i>
		<i>13</i>	<i>1 3 23</i>	<i>13</i>	<i>10 19 4</i>	<i>131 43 18</i>	<i>435</i>	<i>42</i>
<i>Jan.</i>	<i>0 0 0</i>	<i>14</i>	<i>5 8 5</i>	<i>14</i>	<i>4 29 46</i>	<i>141 51 15</i>	<i>445</i>	<i>50</i>
<i>Febr.</i>	<i>5 1 38</i>	<i>15</i>	<i>9 12 48</i>	<i>15</i>	<i>11 10 28</i>	<i>151 59 11</i>	<i>455</i>	<i>58</i>
<i>Mar.</i>	<i>3 1 10</i>	<i>16</i>	<i>7 28 13</i>	<i>16</i>	<i>5 21 10</i>	<i>162 7 8</i>	<i>466</i>	<i>5</i>
<i>April</i>	<i>8 2 48</i>	<i>17</i>	<i>0 2 56</i>	<i>17</i>	<i>0 1 52</i>	<i>172 15 5</i>	<i>476</i>	<i>13</i>
<i>Maii</i>	<i>6 23 44</i>	<i>18</i>	<i>4 7 39</i>	<i>18</i>	<i>6 12 34</i>	<i>182 23 1</i>	<i>486</i>	<i>21</i>
<i>Junii</i>	<i>11 25 22</i>	<i>19</i>	<i>8 12 21</i>	<i>19</i>	<i>0 23 16</i>	<i>192 30 58</i>	<i>496</i>	<i>29</i>
<i>Julii</i>	<i>10 16 19</i>	<i>20</i>	<i>6 27 46</i>	<i>20</i>	<i>7 3 57</i>	<i>202 38 55</i>	<i>506</i>	<i>37</i>
<i>Aug.</i>	<i>3 17 57</i>	<i>40</i>	<i>1 25 32</i>	<i>21</i>	<i>1 14 39</i>	<i>212 46 52</i>	<i>516</i>	<i>45</i>
<i>Sept.</i>	<i>8 19 35</i>	<i>60</i>	<i>8 23 19</i>	<i>22</i>	<i>7 25 21</i>	<i>222 54 49</i>	<i>526</i>	<i>53</i>
<i>Octob</i>	<i>7 10 31</i>	<i>80</i>	<i>3 21 5</i>	<i>23</i>	<i>2 6 3</i>	<i>233 2 45</i>	<i>537</i>	<i>1</i>
<i>Nov.</i>	<i>0 12 9</i>	<i>100</i>	<i>10 18 51</i>	<i>24</i>	<i>8 16 45</i>	<i>243 10 42</i>	<i>547</i>	<i>9</i>
<i>Dec.</i>	<i>11 3 5</i>	<i>120</i>	<i>5 15 37</i>	<i>25</i>	<i>2 27 27</i>	<i>253 18 39</i>	<i>557</i>	<i>17</i>
<i>In Anno Bissextili post Fe- bruarium adde unius diei motum.</i>				<i>26</i>	<i>9 8 9</i>	<i>263 26 35</i>	<i>567</i>	<i>25</i>
				<i>27</i>	<i>3 18 50</i>	<i>273 34 32</i>	<i>577</i>	<i>33</i>
				<i>28</i>	<i>9 29 32</i>	<i>283 42 28</i>	<i>587</i>	<i>41</i>
				<i>29</i>	<i>4 10 14</i>	<i>293 50 25</i>	<i>597</i>	<i>49</i>
				<i>30</i>	<i>10 20 56</i>	<i>303 58 22</i>	<i>607</i>	<i>57</i>

*Tabula Mediorum Motuum Satellitis Saturni*  
*Penintimi, à Cassino detecti Anno 1686.*

<i>Annis Jul. inceunt</i>	<i>Epochæ s . o .</i>	<i>Annis</i>	<i>Med. Mot. s . o .</i>	<i>Diebus</i>	<i>Med. Mot. s . o .</i>	<i>H M</i>	<i>Mot. Med s . o .</i>	<i>Motus Medi. s . o .</i>
1681	✕ 3 23	1	4 10 2	1	4 11 32	1	0 5 29	31 2 50
1686	✕ 5 25	2	8 20 4	2	8 23 4	2	0 10 58	32 2 56
1701	✕ 22 3	3	1 0 6	3	1 4 36	3	0 16 26	33 3 1
1714	✕ 7 5	4	9 21 40	4	5 16 8	4	0 21 55	34 3 7
1715	✕ 17 7	5	2 1 42	5	9 27 40	5	0 27 24	35 3 12
1716	☾ 27 9	6	6 11 44	6	2 9 12	6	0 32 53	36 3 17
1717	☾ 18 43	7	10 21 46	7	6 20 44	7	0 38 22	37 3 23
1718	☾ 28 45	8	7 13 20	8	11 2 16	8	0 43 51	38 3 28
1719	✕ 8 47	9	11 23 22	9	3 13 49	9	0 49 19	39 3 34
1720	☾ 18 49	10	4 3 24	10	7 25 21	10	0 54 48	40 3 40
<i>Menf. An. Co</i>	<i>Med. Mot. s . o .</i>	11	8 13 26	11	0 6 53	11	1 0 17	41 3 45
		12	5 5 0	12	4 18 25	12	1 5 46	42 3 51
		13	9 15 2	13	8 29 57	13	1 11 15	43 3 56
<i>Jan.</i>	0 0 0	14	1 25 4	14	1 11 29	14	1 16 44	44 4 1
<i>Febr.</i>	3 27 34	15	6 5 6	15	5 23 1	15	1 22 13	45 4 7
<i>Mar.</i>	6 20 32	16	2 26 40	16	10 4 33	16	1 27 42	46 4 12
<i>Apr.</i>	10 18 6	17	7 6 42	17	2 16 5	17	1 33 11	47 4 17
<i>Maii</i>	10 4 7	18	11 16 44	18	6 27 37	18	1 38 39	48 4 23
<i>Junii</i>	2 1 41	19	3 26 46	19	11 9 9	19	1 44 8	49 4 28
<i>Julii</i>	1 17 43	20	0 18 20	20	3 20 41	20	1 49 37	50 4 34
<i>Aug.</i>	5 15 17	40	1 6 40	21	8 2 13	21	1 55 6	51 4 39
<i>Sept.</i>	9 12 51	60	1 25 0	22	0 13 45	22	2 0 35	52 4 45
<i>Oct.</i>	8 28 53	80	2 13 20	23	4 25 17	23	2 6 45	53 4 5
<i>Nov.</i>	0 26 27	100	3 1 4	24	9 6 49	24	2 11 32	54 4 56
<i>Dec.</i>	0 12 28	120	3 20 0	25	1 18 22	25	2 17 1	55 5 1
<i>In Anno Bissextili post Februa- rium adde unius diei motum.</i>				26	5 29 54	26	2 22 30	56 5 7
				27	10 11 26	27	2 27 59	57 5 12
				28	2 22 58	28	2 33 27	58 5 18
				29	7 4 30	29	2 38 56	59 5 23
				30	11 16 23	30	2 44 25	60 5 29

*Tabula Mediorum Motuum Satellitis  
Saturni Medii, à Cassino detecti Anno 1671.*

Annis Julia. ineunt	Epoche s o .	Annis	Med. Motus s o .	Diebus	Med. Motus s o .	H M	Med. Mot sex. o .	Med. Mot.
1681	12 16	1	9 17 2	1	2 19 41	1	3 19	1 43
1686	27 6	2	7 4 3	2	5 9 23	2	6 38	1 46
1701	1 17	3	4 21 5	3	7 29 4	3	9 58	1 49
1714	11 43	4	4 27 48	4	10 18 46	4	13 17	1 53
1715	28 45	5	2 14 50	5	1 8 27	5	16 36	1 56
1716	15 47	6	0 1 52	6	3 28 9	6	19 55	2 0
1717	22 30	7	9 18 53	7	6 17 50	7	23 15	2 3
1718	9 32	8	9 25 36	8	9 7 31	8	26 34	2 6
1719	26 34	9	7 12 38	9	11 27 13	9	29 53	2 10
1720	13 35	10	4 29 40	10	2 16 54	10	33 12	2 13
Menf. Anni Com.	Med. Motus s o .	11	2 16 42	11	5 6 36	11	36 31	2 16
		12	2 23 25	12	7 26 17	12	39 51	2 19
		13	0 10 26	13	0 15 59	13	43 10	2 23
Jun. Febr.	0 0 0	14	9 27 28	14	1 5 40	14	46 29	2 26
	10 10 24	15	7 14 30	15	3 25 21	15	49 48	2 29
Mar.	0 21 44	16	7 21 13	16	6 15 3	16	53 8	2 33
Apr.	11 2 9	17	5 8 15	17	9 4 44	17	56 27	2 36
Maii	6 22 51	18	2 25 16	18	11 24 26	18	59 46	2 39
Jun.	5 3 16	19	0 12 18	19	2 14 7	19	3 5	2 43
Julii	0 23 58	20	0 19 1	20	5 3 49	20	6 24	2 46
Aug.	11 4 23	40	1 8 2	21	7 23 30	21	9 44	2 49
Sept.	9 14 47	60	1 27 4	22	10 13 11	22	13 3	2 53
Oct.	5 5 30	8	2 16 5	23	1 2 53	23	16 22	2 56
Nov	3 15 54	100	3 5 6	24	3 22 34	24	19 41	2 59
Dic.	11 6 37	120	3 24 7	25	6 12 16	25	23 1	3 3
In Anno Bissextili post Februa- rium adde unius Diei motum				26	9 1 57	26	26 20	3 6
				27	11 21 39	27	29 39	3 9
				28	2 11 20	28	32 58	3 13
				29	5 1 1	29	36 17	3 16
				30	7 20 43	30	39 36	3 19

*Tabula Mediorum Motuum Penextimi Satellitis Saturni ab Hugenio inventi Anno 1655.*

<i>Annis Jul. inceunt</i>	<i>Epochæ s o .</i>	<i>Annis</i>	<i>Med. Mot. s o .</i>	<i>Diebus</i>	<i>Med. Mot. s o .</i>	<i>Min. Mot. s o .</i>	<i>Max. Mot. s o .</i>	<i>Motus An. J.</i>
1641	♊ 2 48	1	10 20 35	1	0 22 35	0	56 31	29 10
1661	♋ 13 23	2	9 11 10	2	1 15 9	1	53 12	30 6
1681	♌ 27 58	3	8 1 45	3	2 7 44	2	49 33	31 3
1686	♍ 3 28	4	7 14 55	4	3 0 18	3	46 34	31 59
1701	♎ 12 33	5	6 5 30	5	3 22 53	5	4 42 35	32 55
1714	♏ 17 53	6	4 26 5	6	4 15 28	6	5 39 36	33 52
1715	♐ 8 28	7	3 16 40	7	5 8 2	7	6 35 37	34 48
1716	♑ 29 3	8	2 29 50	8	6 0 37	8	7 31 38	35 45
1717	♒ 12 13	9	1 20 25	9	6 23 12	9	8 28 39	36 41
1718	♓ 2 48	10	0 11 0	10	7 15 46	10	9 24 40	37 38
1719	♊ 23 23	11	11 1 35	11	8 8 21	11	10 21 41	38 34
1720	♋ 13 58	12	10 14 45	12	9 0 55	12	11 17 42	39 31
1721	♌ 27 8	13	9 5 20	13	9 23 30	13	12 14 43	40 27
<i>Menf. An. Co</i>	<i>Med. Mot. s o .</i>	14	7 25 55	14	10 16 5	14	13 10 44	41 24
		15	6 16 30	15	11 8 39	15	14 7 45	42 20
<i>Jan.</i>	0 0 0	16	5 29 40	16	0 1 14	16	15 3 46	43 17
<i>Febr.</i>	11 9 54	17	4 20 15	17	0 23 48	17	16 0 47	44 13
<i>Mar.</i>	8 12 2	18	3 10 50	18	1 16 23	18	16 56 48	45 10
<i>Apr.</i>	7 21 55	19	2 1 25	19	2 8 58	19	17 52 49	46 6
<i>Maii</i>	6 9 14	20	1 14 35	20	3 1 32	20	18 49 50	47 3
<i>Junii</i>	5 19 7	40	2 29 10	21	3 24 7	21	19 45 51	47 59
<i>Julii</i>	4 6 26	60	4 13 45	22	4 16 42	22	20 42 52	48 56
<i>Aug.</i>	3 16 18	80	5 28 20	23	5 9 16	23	21 38 53	49 52
<i>Sept.</i>	2 26 12	100	7 12 55	24	6 1 51	24	22 35 54	50 49
<i>Oct.</i>	1 13 30	120	8 27 3	25	6 24 25	25	23 31 55	51 45
<i>Nov.</i>	0 23 24	140	10 12 5	26	7 17 0	26	24 27 56	52 42
<i>Dec.</i>	11 10 42	160	11 26 40	27	8 9 35	27	25 24 57	53 38
				28	9 2 9	28	26 20 58	54 35
				29	9 24 44	29	27 17 59	55 31
				30	10 17 18	30	28 13 60	56 27

*In Anno Bissextili post Februa-  
rium adde unius diei motum.*

*Tabula Mediorum Motuum Satellitis Saturni*  
*Extimi, à Cassino detecti Anno 1671.*

<i>Annis</i> <i>Julia.</i> <i>ineunt</i>	<i>Epochæ</i> s . o .	<i>Annis</i>	<i>Med. Motus</i> s . o .	<i>Debus</i>	<i>Med. Motus</i> s . o .	<i>H</i> M	<i>Mo. Me.</i> ° ' " M	<i>Med. Mor.</i> " . "
1681	Υ 8 40	1	7 6 32	1	0 4 32	1	0 11 31	5 51
1686	Υ 15 50	2	2 13 3	2	0 9 5	2	0 23 32	6 3
1701	Ϟ 11 53	3	9 19 35	3	0 13 37	3	0 34 33	6 14
1714	Ϟ 20 20	4	5 0 39	4	0 18 9	4	0 45 34	6 25
1715	≡ 26 52	5	0 7 10	5	0 22 42	5	0 57 35	6 37
1716	Π 3 23	6	7 13 42	6	0 27 14	6	1 8 36	6 48
1717	Υ 14 27	7	2 20 13	7	1 1 46	7	1 19 37	7 0
1718	Ω 20 58	8	10 1 17	8	1 6 18	8	1 31 38	7 11
1719	Ϟ 27 30	9	5 7 49	9	1 10 51	9	1 42 39	7 22
1720	m 4 2	10	0 14 20	10	1 15 23	10	1 53 40	7 34
<i>Mens.</i> <i>Anni</i> <i>Com.</i>	<i>Med. Motus</i> s . o .	11	7 20 52	11	1 19 55	11	2 5 41	7 45
		12	3 1 56	12	1 24 28	12	2 16 42	7 56
		13	10 8 27	13	1 29 0	13	2 27 43	8 8
<i>Jan.</i>	0 0 0	14	5 14 59	14	2 3 32	14	2 39 44	8 19
<i>Febr.</i>	4 20 41	15	0 21 30	15	2 8 5	15	2 50 45	8 30
<i>Mar.</i>	8 27 46	16	8 2 34	16	2 12 37	16	3 1 46	8 42
<i>Apr.</i>	1 18 27	17	3 9 6	17	2 17 9	17	3 13 47	8 53
<i>Maii</i>	6 4 37	18	10 15 37	18	2 21 42	18	3 24 48	9 4
<i>Jun.</i>	10 25 18	19	5 22 9	19	2 26 14	19	3 35 49	9 16
<i>Julii</i>	3 11 27	20	1 3 13	20	3 0 46	20	3 47 50	9 27
<i>Aug.</i>	8 2 9	40	2 6 26	21	3 5 18	21	3 58 51	9 38
<i>Sept.</i>	0 22 50	60	3 9 38	22	3 9 51	22	4 9 52	9 50
<i>Oct.</i>	5 8 59	80	4 12 51	23	3 14 23	23	4 21 53	10 1
<i>Nov.</i>	9 29 41	100	5 16 4	24	3 18 55	24	4 32 54	10 12
<i>Dec.</i>	2 15 50	120	6 19 17	25	3 23 28	25	4 43 55	10 24
<i>In Anno Bissextili post Februa-</i> <i>rium adde unius Diei motum.</i>				26	3 28 0	26	4 55 56	10 35
				27	4 2 32	27	5 6 57	10 46
				28	4 7 5	28	5 17 58	10 58
				29	4 11 37	29	5 29 59	11 9
				30	4 16 9	30	5 40 60	11 21

Motibus mediis Satellitum ad hunc modum constitutis, proveniunt Revolutiones eorum jam veris proximæ, scilicet

	D	h	'	"
<i>Primi sive Intimi</i>	1.	21.	18.	26 $\frac{1}{2}$
<i>Secundi Penintimi</i>	2.	17.	41.	10 $\frac{1}{2}$
<i>Tertii sive Medii</i>	4.	12.	25.	10
<i>Quarti Hugeniani</i>	15.	22.	41.	28
<i>Quinti sive Extimi</i>	79.	7.	46.	00

Posito autem, juxta regulam Naturæ (saltem in hoc nostro Systemate) universalem quæque tam in Jovialium ac Lunæ motibus, quam Planetarum Primariorum circa Solem, obtinet, Vires centrum Saturni petentes esse in duplicata ratione distantiarum reciproçè, ac proinde Cubos distantiarum à centro esse ut quadrata Temporum periodicorum; ex data distantia & periodo *Hugeniani*, fiunt reliquorum distantia ut sequitur.

	<i>Semidiam. Annuli</i>	<i>Semidiam. Globi</i>
<i>Dist. Primi</i>	1.9289	4,3400
<i>Secundi</i>	2.4708	5,5593
<i>Tertii</i>	3.4508	7,7643
<i>Quarti</i>	8.0000	18,0000
<i>Quinti</i>	23.3146	52,4578

Quæ quidem distantia cum D. *Cassini* observatis satis quadrant. Quatuor autem interiores Satellites juxta planum Annuli Saturni orbitas suas describunt proximè; in plano. *sc.* Æquatoris nostri plano quoad sensum parallelo, quicquid in contrarium proferant nonnulli. Quintum vero orbem situ paulo diversum à cæteris describere, nuperprehendit D. *Jac. Cassinus* prioris filius & virtutum hæres, ut videre est in Actis Academiæ Scientiarum *Parisiensis* Anni 1714. Sed hæc autem omnia propriis oculis contemplari, atque penitus introspicere jam ipsi accingimur.



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II. *The rest of the Treatise of that Learned Antiquary Dr. John Tabor of Lewes (whereof the First Part is publish'd in N<sup>o</sup> 351. of these Transactions) concerning the Site of the ancient City of Anderida, and other Remains of Antiquity in the County of Suffex.*

**T**HE former Part of this curious Treatise having found a just Esteem among several worthy Members of the Royal Society, who are Lovers of Antiquity, at Their instance we have adventur'd to insert here the Remainder thereof; entreating our Philosophical and Mathematical Reader, to indulge the Liberty we now take, of breaking in upon the usual Subject of these Papers.

Where Tacitus speaks of Britain and its Affairs, his Descriptions are so lively deliver'd, that one would think himself had been here, with his Wife's Father *Agricola*; and where he mentions the *Irish* <sup>1</sup> Prince, the Expression by him us'd seems to give Strength to such a Supposition.

The gaining the Southern part of this Island, was the greatest, if not the only Acquisition, made to the Roman Empire, from the Death of *Tiberius* to the Sixth Year of *Claudius*; which we may well suppose was not pass'd over in silence by that excellent Historian *Tacitus*: But his Four Books of Annals, which contain'd the Transactions of those Nine Years, we have reason enough to fear, are irretrievably lost. From the mention *Suetonius* makes of *Claudius* his Expedition hither; 'tis

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commonly

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<sup>1</sup> Tac. Agric. cap. XXIV.

commonly insinuated his Conquest here <sup>2</sup> cost no Blood. Our Countryman *Bede*, we may see, was of that opinion; because, in the Account given by him of *Claudius*, the Words of *Suetonius* <sup>3</sup> are copied. But *Dio Cassius*, from whom we have the most particular Information of that War, gives a quite different Relation of the Matter: He takes notice of at least Four Battels, fought with the *Britons* ( before *Claudius* came over ) by *Anlus Plantius*; who had *Flavius Vespasianus*, *Flavius Sabinus*, and *Hosidius Geta*, that commanded under him: In the first Conflict, *Cataratacus* was defeated; in the second, *Togodumnus*, and, as may be inferr'd from his Words afterwards, slain. From the manner of his delivering the Story, all those Battels seem to have been fought, South of the River *Thames*, and North of the *Sylva Anderida*, except the last; and that in the first Campaigne the Conquests of *Plantius* could not have extended beyond *Kent* and *Surry*: For it's likely <sup>4</sup> that the Two first Actions happen'd about the Skirts of the *Sylva Anderida*, Eastward of the River *Medway*; and the Third, which held Two Days, on the Banks of that River; because, from the River, where they were routed Two Days successively, the *Britons* retiring, assembled <sup>5</sup> their Strength again before their Fourth Overthrow.

<sup>2</sup> Suet. Claud, cap. 17. *Ac sine ullo praelio aut sanguine, intra paucissimos dies parte insula in ditionem recepta, sexto quam profectus erat mense Romam rediit* <sup>3</sup> Beda Ecclesi. Hist. Gent. Angl. Lib. I cap. 2.

<sup>3</sup> Beda Eccles. Hist. Gent. Angl. Lib. I cap. 3.

4 Dionis Caffii Hist. Rom. l. lib. LX. Claud. V p 768. A. Οἱ δὲ Βρε-  
τανοὶ μὴ θεοσδοκῆσαι εἰς αὐτοὺς δι' ὅπερ ἐπιμυθάνοντο ἦζεν. ὁ θεοστυμωλέτης ἦν,  
ἡ μὲν ὁδὸς τότε εἰς χεῖρας αὐτοῖς ἦλθον, ἀλλ' ἐς τε τὰ ἔκρη καὶ εἰς τὰς ὕψας κατέπε-  
ρον. ἐλπίσιντες σφᾶς ἄλλως κησάτευσεν. αἶψ' ὅπερ ὅτι τὰ κομπερὺς τῆς ἐλπίδος ἐγε-  
ρον, διακνήϊς αὐτοὺς ἀναπέσσυτο. ὁ δὲ Πλάτων πολλὰ μὲν παρὰ γὰρ ἀ-  
ναμνηστῆς σφᾶς ἔχεν, ἐπειδ' εὖρεσσι τότε πρῶτον μὲν Καίσαρ ἐτάκον, ἐπειτα Το-  
ρμόδεμον Κωκυβελλίνου παιδὸς ἐκίχηεν.—εὐρύνων δ' αἰένων—θεσσω ἦεν, ὡς  
δὲ πρὸς αὐτὸν πᾶσι ἐγένοντο. <sup>5</sup> Pag. 678. D. Ἀναρχοῦσάων δ' ὠπτεῖσθαι  
ἐν Βρετανίᾳ. ὅτι πρὸς Ταμίσιον ποταμὸν καὶ ὅς τε τὸν ὠκεανὸν ἐκβάλλει,  
πυμυμωρῶτος τε αὐτῷ Νημεῶς.

throw, in that part of *Kent* which borders on the *Thames*, not far from its entrance into the Sea; and having pass'd it, were follow'd by *Plantius* his *Germans*, and on the other side put to flight; which was the Fourth Action mention'd by *Dio*. *Claudius* having been sent for, comes the Second Year with powerful Succours to the Assistance of *Plantius*; who with his Forces waited his Arrival near the *Thames*, not unlikely still where he quarter'd in the Winter; which perhaps was in that large strong Camp, as yet to be seen <sup>6</sup> not far from *Bromly* in *Kent*, on the River *Ravensbourn*. The Empe-  
rour joining him <sup>7</sup>, immediately cross'd the *Thames*; overthrew the *Britons* posted on the other side to resist him; advanced to *Cynobelin's* chief Residence *Camalodunum*, and took it: Then receiving Homage of some States, return'd to *Rome*.

Considering therefore that *Claudius* staid but Sixteen Days <sup>8</sup> in this Island, we must conclude his Dispatch was great; and that his Progress could not have been through more Parts than *Kent*, *Essex*, *Hertfordshire*, *Middlesex*, and *Surry*. As to what else relates to the *British War* in the time of *Claudius*, save that Three Years after *Titus* rescued his Father *Vespasian* when in great danger, we have no Account from *Dio*. But where *Suetonius* <sup>9</sup> treats of *Vespasian's* Life; we are told, when that Emperour commanded in *Britain* for *Claudius*; that he fought Thirty Battels, subdu'd Two of the

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most

<sup>6</sup> Camden Brit. Edit. 1695. Col. 213. c. <sup>7</sup> Dion. Cassii. Hist. Rom. Lib. LX. pag. 677. B. Κἀντεῦθεν τὰ μὲρ περὶ, τὰ δὲ καὶ διὰ τῶν ποταμῶν πορεύμενοι, πρὸς τὴν πρὸς Ὀκεανὸν ἀφίκετο καὶ περιωδεῖς ἐς τὴν ῥατταρίαν, σωσάμενοι τὴν στρατιάν; πρὸς τὴν Ταυίσα ἀναμύσαντων αὐτὸν καὶ πρὸς λαδῶν σφᾶς, ἐπὶ τὸν τε ὀπίσκειν, καὶ τοὺς βαρβάρους πρὸς τὴν ἐπὶ τὸν ὄρεον ὡς σωσάμενοι ἐς τὴν ἐλθόντων, μάχῃ τε ἐνίκησε <sup>8</sup> Dion. Lib. LX. pag. 677. B. Ἡ δὲ τε ἐς τὴν Ρώμην ὁ Κλαύδιος, ἔξ μύνης ἀποδημήσας (ἀφ' ὧν ἐκκρίδεται μόνος ἐν τῇ Βρεττανίᾳ ἡμεῖς ἐπείνομεν.) <sup>9</sup> Suet. Vespasian. cap. 4.

most powerful Nations, won Twenty Towns, and brought the Isle of *Wight* under the *Roman* Obedience. Of which Actions, besides what might have been said in the lost Books of Annals; *Tacitus*, in other Pieces of his, largely <sup>1</sup> hints, that when *Claudius* rul'd, *Vespasian's* Behaviour and Success in this Island, shew'd to the World his Conduct and Courage in the Affairs of War: The same is also taken notice of <sup>2</sup> by *Dio*. From his Conquest of the Isle of *Wight*, it may be imply'd, the Stage of his Actions here, was in those Countries which border on the South Channel rather than in the North: Since therefore the Clime, the Soil, and the more ready Conveniencies for foreign Trade and Correspondence, might entitle this Part of the Land, to sustain as numerous, as stout, and as experienc'd a People as any other (because *Caesar* <sup>3</sup> takes notice they not only lent Aids to the *Veneti* in their Revolt, but were wont to assist the *Gauls* in most of their Wars against <sup>4</sup> the *Romans* : ) And whereas no Historian afterwards mentions any Disturbance given to the *Romans* from the Southern Parts; we may conclude, *Vespasian* entirely subdu'd them; and that before he left the Island, the Methods he establish'd for securing Peace, were no way inferior to those he had shewn in making War.

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<sup>1</sup> Tacit Agricola. cap. xiii. Divus Claudius auctor operis transvexit legionibus auxiliisque, & assumpto in partem rerum Vespasiano; quod initium ventura mox fortuna fuit, domita gentes, capti Reges, & monstratus satis Vespasianus. Tacit. Hist. Lib. III. cap. xlv. Et Britanniam inclitus erga Vespasianum favor, quod illic secunda Legioni à Claudio præpositus, & bello clarus egerat, non sine motu adjunxit ceterarum.

<sup>2</sup> Dion Cass. Hist. Rom. Lib. LXV. p. 736. C. ἡ γὰρ τῶν ἀνθρώπων εὐνοία πολλὴν τῷ αὐτῷ — τὸ ἐν τῇ Βρετανίᾳ δεῖμα καὶ ἐν αὐτῇ ἐν γαστρὶ πλεῖστα εὐχόρια.

<sup>3</sup> De Bello Gal. Lib. I. l. octies p̄bi ad id Bellum Cisp̄it̄is, Lexobios, &c. auxilia ex Britannia, quæ contra eas Regiones posita est, accersunt.

<sup>4</sup> Idem Lib. IV. Tamen in Britanniam proficisci contendit, quod, omnibus fere Gallicis Bellis, hostibus nostris inde subministrata auxilia succurrerent.

The *Romans* well knew, that those who were Strangers to Civility, could not without great Difficulty be kept in Obedience: As soon therefore as the Countries they had conquer'd, were reduced to some degree of Quiet; they endeavour'd to make the People in love with their Government, by introducing their Arts and Customs among them: From that inconsiderable Instance recorded <sup>5</sup> by *Pliny*, we may see, how ready the *Romans* were, to oblige the People under their Power, with any Curiosity that might entertain their Sences, in order to endear them to the Authority they had over them. ( He tells us, Cherries were not known in *Italy*, till the 680th Year of *Rome*, when *L. Lucullus* first brought them thither from *Pontus*; and that in a Hundred and Twenty Years, they were so increas'd, that not only many other Countries, but *Britain* also was supply'd with them; which must have been about Three Years after *Claudius* himself had been here. The usual Landing from *Rome* being then in the County of *Kent*; that Fruit without question was there first planted; and the Soil well agreeing with it, may be the reason that the best and greatest Quantity of it is yet there to be had.)

*Agricola*, in the Second Year of his Lieutenantcy here, when in Winter-Quarters, pursu'd the same Maxims ( which *Tacitus* terms *Saluberrima Consilia*; and, as it may be inferr'd from an Expression of <sup>6</sup> *Cæsar* conducive to the same End ) to gain the *Britons*, by making them acquainted with the *Roman* Manners: He not only in private perswaded, but publicly help'd  
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<sup>5</sup> *Plin. Lib. XV cap xxv.*      <sup>6</sup> *De Bell. Gallic. Lib. I. Horum omnium fortissimi sunt Belgæ: Propterea quod à cultu atque humanitate Provincie longissimè absunt, minimeque ad eos Mercatores sæpe commeant, atque ea quæ ad effeminandos animos pertinent, important.*

and encourag'd them to build Temples, Places for common Assemblies, and private Houses after the *Roman* Mode : He took care to have the principal Youth instructed in the Liberal Arts : He allur'd them to affect the Habit of the *Romans* : And last of all, to engage them the more firmly, help'd them to a Taste of the *Roman* Luxury and Goodfellowship, by introducing the Use of shady Piazzas and Baths<sup>7</sup>, and their way of Banqueting. But here, *Tacitus* may be understood to speak of what was done in order to civilize the Northern Parts of this Nation, where *Agricola's* Presence was required : The Southern was, we may suppose, softened and quieted by the same Methods near Forty Years before, when reduced by *Vespasian*

From hence it may be inferr'd ; that should never any other Tokens of the Antiquity of these Works be found ; yet would the Bath denote the Age of the Pavement, and set it near as high as the most early Time, that the *Romans* had any real Authority in this Island.

As by the Loss of some of the Annals of *Tacitus*, we may have been depriv'd of the most early History of this County ; so likewise, for want of antient Religious Houses ; there has been little or no Accounts left of its Circumstances, in the Times next after the *Roman* Authority expired here. *Malmsbury*<sup>8</sup> says, that in his Time, there were here only the Abbies of *Battell* and *Lewes*, and those not long erected. The earliest Mention made of it, is by<sup>9</sup> *Bede*, who informs us, that Bishop *Wilfrid*, in the Year 678. being thrust out of his Province of *Northumbria* by King *Ecgfrid*, settled at *Selfey* in 680. and staid Five Years, labouring  
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<sup>7</sup> Tacit. Agric. cap. xxi.  
Angl. Lib. II.

<sup>8</sup> Gul. Malmsb. de gestis Pontific.  
<sup>9</sup> Bede Hist. Eccles. Lib. IV. cap. xiii

in the Conversion of the neighbouring Parts; but of what else relates to the County, save the miserable Ignorance of the Inhabitants, and the Number of Families, he has left no Account. *Bede* spent most of his Time in the Monasteries of *Wiremouth* and *Farrow*, and travel'd little; so, that considering the Distance from thence to this County, and the different Governments and Interests that lay between, he may well be excus'd for the few Particulars he has left us of it.

The next Records we have to view are those of *Ethelwerd*, the *Chronicon Saxonicum*, and *Henry* Arch-deacon of *Huntingdon*. But that you may the more clearly apprehend the antient State of this County; look into the best Map of it you can get. At the West End, you will find *West-Harling* and *Stansted*, distant from each other Six or Seven Miles; imagin a streight Line to be drawn from *Harling* to *Bourne* near *Pevensey*, and another to be drawn from a Point which must be little South of *Stanstead* to *Brighthelmstone*; What lies North of these Lines is the Weald or Lowlands, formerly the *Sylva Anderida*; that which is comprehended between these Lines, and bounded by the Sea, from *Brighthelmstone* to *Bourne*, is the *Downs*, so famous for their pleasant Situation and Fruitfulness. The Part South of these Lines, is a flat champain Ground, ending like a Wedge at *Brighthelmstone*. These two last Parts were those only that were inhabited in *Bede's* Time; they contain not more than Two Fifths of the whole County; which must be the reason why *Bede* said, *Suffex* <sup>1</sup> consisted not of more than 7000 Families or Farms; whereas in another place he computes *Kent* to have 15000 Families.

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In the three Accounts <sup>1</sup> above-mention'd 'tis agreed, that in the Year 477. *Elle*, with his Three Sons *Cymen*, *Wlencing*, and *Cissa*, landed his Forces at *Cymenes-Ora* ( which from a Charter of King *Cedwallas* to the Church of *Selfey* the learned <sup>2</sup> *Camden* proves to be about *Wittering* near *Selfey*; ) not far from which he routed the *Britons*, and drove them into the *Weald* ( *Andredesleige* ): Their farther Progress is most distinctly and naturally deliver'd by the Archdeacon of *Huntingdon*, in these Words; *Saxones autem occuparunt littora Maris in Sudsexe, magis magisque sibi regionis spatia capeffentes, usque ad nonum annum adventus eorum. Tunc vero cum audacius regionem in longinquum capefferent; convenerunt Reges & Tyranni Brittonum apud Wercresdesburne, & pugnauerunt contra Elle & filios suos, & fere dubia fuit victoria. Uterque enim Exercitus valde lesus & minoratus, alterius congressum devovens, ad propria remearunt. Misit igitur Elle ad compatriotas suos auxilium flagitans.*

This County having been invaded in the most Western part of it by the Saxons; if what they did afterwards, was to possess themselves of it; their Progress must have been from West to East. And so much *Henr. Huntingdon's* Words plainly imply. He says farther, they were Eight Years about it; which, if we consider the Circumstances of the Country, 'twill be no great wonder it should take up so much Time; unless their Forces had been very great, which we have no warrant from any History to suppose: For the *Weald* then uncultivated, must have been most difficult to pass, even in the driest Summers. The *Downs*, like a Wall ( with a Terras-Walk on the top ) have a very steep  
Descent

<sup>1</sup> Ethelward Hist. Lib. I. Cap. 5.  
Hen. Hunt. Hist. Lib. II.

Chronic. Saxon. Ann. CCCCLXXVII.  
<sup>2</sup> Camden Brit. Suffex.



Descent into it, their whole Length; excepting, that every Ten Miles, or thereabouts, they have deep Channels through them to afford Passage for the Rivers into the Sea: Therefore, what was then habitable, being thus canton'd out into so many Parcels by the Rivers; nothing could be more difficult to gain, than those Cantonments; were there any Forces to defend the Passes that should have been attempted; the Rivers being deep and muddy, and the Morasses on each side broad and boggy: Hence we may conceive, 'twas no very difficult Task for the *Britons* to defend, nor an easy one, for the *Saxons* to gain the Country. And indeed, the many old Camps, still to be seen on the *Downs*, are an Evidence that scarce any part escaped being a Scene of War. Mr. *Camden* mentions but two, *Cisbury* and *Chenkbury*. In the new Edition of his Works Dr. *Harris* has added Three more; a *Roman* Camp at the *Brile* near *Chichester*, *St. Rooks-hill*, and *Gons-hill* near the West Limits of the County. It may not be improper here to insert an Account of the rest; in which, I shall first take notice of those that are on the North Edge of the *Downs*, and overlook the *Weald*.

First, *Chenkbury*, mention'd by Mr. *Camden*, Two Miles West of *Steyning*, and about Three Miles North of *Cisbury*; 'tis circular; its Circumference about two Furlongs. From *Chenkbury* Eight Miles East, over *Poynings*, is a very large one, an Oval, not less than a Mile round; accessible at one narrow Neck only, and that fortify'd, with a deep broad Ditch, and a very high Bank: I could never learn any other Name it has gone by, than *Poor-Mans Wall*; perhaps from its having been a Security to the distressed *Britons*. About Three Miles East from thence, is *Wolfsbury*, on a Hill, projected beyond the rest of the *Downs*, like a Bastion; it comes near a Circle in shape; its Diameter a little

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more than a Furlong. Near Three Miles East of *Wolsenbury*, on the highest part of the *Downs* in that Quarter, is a Camp, near square, about 60 Rods long, and 50 broad; much like a *Roman* Camp; the side next the North is secur'd by the Precipice of the Hill, which is both very deep and steep; the other Three Sides have each their *Portæ* after the *Roman* manner still very visible; the Ditch seems to have been not less than Eleven Foot broad; but the Ground having been plough'd, the Bank is but low: This is call'd *Ditchling*, as is the old Town under it. Near Seven Miles farther East, and a Mile and half East of *Lewes*, is the last on the North Edge of the *Downs*; it goes by the Name of *Caburn*; which perhaps is but a Corruption of the *British* Word *Cadir*; the Parish below it still retains its *British* Name *Glynd*: This is a round Camp, scarce Three Furlongs in Circuit; its Ditch very broad and deep, and the Rampart within very high; the Places where the Tents were pitch'd are yet visible; which, from the Strength of the Out-Works, intimates that those within held it no small time. Near a Quarter of a Mile West of it, there is a strong Work much larger, but not so perfect; yet enough to shew, it was made to secure a Power, that might lie there to bridle those in the strong Camp, and prevent their making Excursions towards *Lewes*.

The Camps on the Southern Limits of the *Downs*, are *St. Rooks* near *Chichester*. *High-Down*, a small Square, Four Miles East of *Arundell*, and in the Parish of *Goring*. *Cisbury*, Four Miles South-West of *Steyning*. *Hollingbury* is the only one in the middle of the *Downs*, Two Miles North of *Brightelmstone*, and Three Miles South of *Ditchling*; 'tis a Square; the *Portæ* still remaining; it contains about Five Acres. A Mile East of *Brightelmstone* on the top of a Hill, half a Mile from the Sea,

Sea, is a Camp, which has a triple Ditch and Bank ; this also is a Square, only the Corners are rounding ; the outmost Trench measures about three Quarters of a Mile. In the Parish of *Telfcomb*, about Five Miles East of the last, are two, but both imperfect ; the Cliff is a South-Fence to One ; the Other is a Mile distant from it ; their West Sides are both finish'd with very able Works ; they were design'd for Squares, and to contain 12 or 15 Acres. At *Meeching* or *Newhaven*, on the Point of the Hill, which overlooks the Harbour's Mouth from the West. is a Fortification which they call *the Castle* ; its Banks are very high, the Shape near half oval, containing about Six Acres ; formerly it might be much more, because the Cliff, which forms the Diameter, every Year more or less moulders away, and falls into the Sea. Near a Mile East of *Seaford* is another call'd also *the Castle*, bounded by the Cliff on the South ; its Figure almost semicircular, the Trench and Rampart large, inclosing Twelve Acres. Three Miles East of *Cukmere Haven* is the last, near a narrow Pass coming up from the Sea call'd *Burling-gap* ; it incloseth a Hill nam'd *Belltout* of a half oval Shape ; the Works have the same Figure, and measure about three Quarters of a Mile ; the Cliff here also makes the Diameter.

Though neither History nor Tradition, has handed to us any Relation, when either of these Works were made or by whom us'd (except *Cisbury* by *Cissa*) yet from this View we may conceive, the Calamity of War once rag'd in all these Parts : that the Ground was disputed inch by inch : that in the Attack, as well as Defence of it, the Pick-Axe and Spade, were as much made use of, as the Sword : and lastly, that, unless the Aggressors were very numerous, eight Years was no long time taken up, in dispossessing the Inhabitants of this fast Country.

Some may imagine, many of these Camps were made by the *Danes*; but by what may be observ'd from the History of those Times, that People seem'd not to be so formal an Enemy, as to prolong War by Encampments: Their Refuge was in their Fleets that always attended them; so that, when likely to be vigorously oppos'd, they betook themselves to their Ships, and suddenly invaded another Part where was less Opposition: and what they could not carry with them, consum'd with Fire and Sword. Thus continually harassing the Nation by their hasty and rapacious Visits, they exhausted it of its Riches and Strength, and as it were imitating the Quality of the Faulcon their Ensign, they flew the Prey to a Stand, and then seiz'd it.

The Archdeacon of *Huntingdon*, in the Prologue or Dedication of his Annals, to *Alexander* Bishop of *Lincoln*, assures his Diocesan, that he compil'd his History from Chronicles reserv'd in ancient Libraries: no question therefore, when speaking of the *Saxons* here, he had good Authority to say ( as above cited ), *magis magisque sibi Regionis spatia capeffentes*; and that no other Meaning could belong to it; than that they carried their Conquest from West to East, *in longinquum* lengthways. Had they entirely made themselves Masters of the Country, 'twould have been too late: But before they had wholly gain'd it, the *Britons* assembled against them; the *Saxon* Chronicle says *neab*, i. e. *propè*; *Ethelwerd*, *juxta*; or, as *Huntingdon* has it, *apud Mercere Desburne*; where a Battle was so hard fought, that each Side had enough on't, and retir'd. The *Saxons* were so diminish'd, that *Ella* was oblig'd to send for more Forces. This Action was in the Ninth Year after *Ella's* first footing here, Three Years before *Hengist's* Death, *Ann. Dom.* 485. It so weaken'd *Ella*, that we hear no more of him till he receiv'd his Supplies.

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from *Germany* ; which came not, according to *H. Huntingdon*, till the first Year of the Emperour *Anastasius*, Three Years after *Hengist's* Death, and Six Years after the hard Battel, viz. *An. Dom.* 491.

Being thus strengthened, *Ella* mov'd again, besieg'd *Anderida* ( in *Huntingdon's* Words, *Urbem munitissimam* ) at last forced the Place ; and by reason of the stout Resistance the Defendants made, Savage like, left not a Soul alive, and raz'd the City, which in *Huntingdon's* Time remain'd desolate.

As to the Field where the Battel was fought ; the *Saxons* extending their Power Eastward, the Check that was given them, in all probability must have been where they push'd on their Victories ; and it being near ~~Mercredesburn~~, this *Bourne* near *Pevensey* may be the Place meant, since it sounds like the latter part of that Name ( for there not being a West *Bourne* that it relates to, the Name of it may rather be *Esbourne* than *East-Bourne* ; ) and likewise that *Anderida*, the *Britons* last Stake and Support, was not far from it. 'Tis probable therefore the Battel was fought on the *Downs*, between the Camp last mention'd at *Burling-Gap* and *East Bourne* ; for there are no where on the *Downs*, that I have seen ( and there are few Parts of them that I have not often view'd ), Marks of a greater Battel than there ; because, from the top of that very high Cliff, by the Inhabitants call'd *The Three Charles* ( and by Mariners *Beachy-Head* ) to *Willington Hill*, which is four Miles, the Ground is full of large *Tumuli* or Places of Burial ; and in many parts within that Tract, where the Position of the Ground seems to offer, there are deep Trenches and Banks, which one would imagin were Breast-Works made to defend the Front of an Army ; and the *Tumuli* on each side of them seem to shew, there was no small Struggle, in forcing as well as defending them. Tha:

The Learned and Judicious Mr. Somner <sup>1</sup> dislikes, that the Site of *Anderida* should be fix'd at *Newenden*, and is inclin'd to assign some Place in *Suffex* for it: But from a modest Deference to the Opinions of the Learned *Camden* and *Selden*, he drops the matter.

But let us see, what our more elder Historians say of it; *Henry of Huntindon's* Words are, *Et quia tot illi damna toleraverant Extramuri, ita Urbem destruxerunt, quod nunquam postea reedificata est. Locus tantum, quasi nobilissima urbis, transcurrentibus ostenditur desolatus. Mathew of Westminster* says, *Locus autem Civitatis usque hodie transcurrentibus ostenditur desolatus. Mansit ergo ibidem Ella cum tribus Filiis suis, & Regionem illam, quæ usque hodie Anglicè Southsex, Latine autem Regio Australium Saxonum dicitur, colere cepit.* From the Expressions above-cited, it may be suppos'd the Ground where that City stood was not quite forgot, in either of those Historian's Days. *Henry of Huntindon* being the elder by 100 Years ( had *Newenden* been the Place ), his Words might have been true, in saying it was desolate: But 'tis very improbable *Mathew of Westminster* should have said so likewise; or at least, not taken notice of the Act of Piety and Charity of Sir *Thomas Albuger*, who, in his Time, had newly erected a Monastery at *Newenden* <sup>2</sup> for the *Carmelites* who came from *Palestine*: But let that pass: what Authority Mr. *Camden* had for saying <sup>2</sup> *Hengist* sent for *Ella* out of *Germany*, to help him reduce *Anderida*, is not to be found. From the Accounts above stated, and others that might be produced, it is clear, that *Hengist* was dead Three Years before the Siege was laid to *Anderida*. In the Time of *Hengist's* Life, we find, for Eight Years

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<sup>1</sup> Somner's *Roman Ports and Forts in Kent*, p. 106.  
*Brit. Kent Edit.* 1695. Col. 211.

<sup>2</sup> *Camd.*

Years *Ella* had enough to do in *Suffex*; and the Blow he had given him the Ninth Year at *Werredeburne*, oblig'd him to be quiet the other two Years of *Hengist*, and till his Succours ( as above-mention'd ) came to him from *Germany*. Besides, we have not the least Hint from any of our Historians, that *Anderida* was an Eye-fore, either to *Hengist* or his Son *Esk* after him; or that *Ella* assisted the *Kentish Saxons*, or the *Kentish Saxons Ella* in reducing it: Therefore this must be a Supposition-only of Mr. *Camden*, in order to give Strength to the Notion of *Anderida's* being at *Newenden*. Taking no notice therefore of that Supposition, we may consider *Newenden* is on the *Kent* side of the *Limen* ( for so is the River *Rother* call'd <sup>3</sup>. in the *Saxon Annals*, and by *Mathew Westminster*; and the Mouth of it nam'd *Portus Limeneus*, and *Limene* by *Ethelwerd* <sup>4</sup> and *Henr. Huntindon*;) and that *Kent* having been subdued by *Hengist* and his *Saxons*, near Forty Years before; the Town at the Mouth of the *Limen*, and the rest, if any, up the Stream on the side of *Kent*, were also part of their Conquest.

Furthermore, after it had cost *Ella* so much Time, and no doubt Pains too, in reducing the plain Ground of *Suffex*, 'tis not likely he should call more Forces out of *Germany*, that he might lead them Thirty Miles, through the Difficulties of the great Wood ( which he must have done if *Newenden* were the Place, ) to besiege a City, so far from his own, and within the *Kentish-Saxon* Limits, especially if there's any heed to be given to the Words of *Math. Westminster* before cited; who, after relating the sad Fate of the Inhabitants and  
City

<sup>3</sup> Chron. Sax. A. Dom DCCCXCIII. Mat. Westm. Fl. Hist. A. Dom, DCCCXCII.

<sup>4</sup> Ethelwerd. Lib. III. cap. iii. A. D. DCCCXCIII. Hen. Hunt. Hist. Lib. V. Alfr. Reg. an. 19.

City of *Anderida*, immediately subjoins, *Mansit ergo, &c.* *Ellia and his Sons resided there* ( i. e. in that part of *Suffex* where *Anderida* was ), and began to cultivate and improve the Country.

In the last place, from the Use made of *Anderida* by the *Romans*, 'tis not likely ( as Mr. *Somner* <sup>5</sup> judiciously hints ) its Place was at *Newenden* ; for being one of the Stations, under the *Præfectus littoris Saxonici*, where Forces were quarter'd, to have a watchful Eye on the Sea, when ever the *Saxon* *Pyrats* came to infest the Coast : We may suppose it, like the rest of the Garisons under that Officer, conveniently situated for the same purpose ; as were *Branodunum* <sup>6</sup> *Brancafter* at the North Point of *Northfolk* ; *Gariannonum*, *North-Yarmouth*, or very near it ; *Othona*, *Ithanchester* in *Dengy Hundred*, in *Essex*, some Ages since swallowed up by the Sea ; *Regulbium*, *Reculver* in *Kent* ; *Putupis*, *Richborow* ; *Dubris* *Dover* ; *Lemannis* ( which from the *Saxon Chronicle* <sup>7</sup> we must look for, Four Miles East of *Appledore* ) probably *New Romney*, all situate near the Sea, on Ground which had a full Prospect of the Sea : whereas *Newenden* lies low, at least Eight Miles within *Appledore*, on a turning of the River, where the Land Eastward must have cut off any Prospect of the Sea. To all this may be added, that the *Romans* having a *Numerus*, Cohort. or Battalion of the *Tur-nacenses*, in Garison at the *Portus Lemanis* on the Mouth of the Haven, we may suppose they knew how to husband their Strength to better purpose, than to place another

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<sup>5</sup> *Somner Rom. Ports and Forts*, pag. 105.  
<sup>6</sup> *Not. Imperii d. Pan-*  
*cirol. cap. lxxiii. pag. 162.*

<sup>7</sup> *Chron. Sax. A. Dom. DCCCXCIII.*  
*Tum appulerunt (sc. Dani) in Limen ostium, cum CCL. Navibus. Su-*  
*per eum Fluvium traxerunt suas Naves usque ad sylvam, quatuor millariis*  
*ab exteriore parte æstuarii; ibique expugnaverunt quoddam munimentum*  
*(sc. Apuldre.)*



another Garifon to watch the Motions of the Saxon Rovers, Twelve Miles up the little River, quite out of sight of the Sea, where they could be of no Service.

Those who would have the Seat of *Anderida* to have been at *Hastings*; let them look on these Words of *Henr. Huntindon* <sup>1</sup> (*Haraldus rex Anglorum, eadem die reversus ad Coutrwic cum summa letitia, dum pranderet, audivit nuntium dicentem sibi, Willielmus dux Normannia littora Australia occupavit, & castellum construxit apud Hastings,*) and they will conclude *Hastings* was not a desolate place, in the Ages of the Historians, who affirm *Anderida* was: If at *Pevensey*; that Place was so far from being raz'd by *Ella*, that even after the *Norman* Conquest it remain'd a strong Castle, where *Odo*, Bishop of *Bayon* and his Forces sustain'd a Six Weeks Siege; and for want of Provision were oblig'd to surrender to *K. William II.* At this time there is so much of *Pevensey* standing, that perhaps 'tis the greatest and most entire Remain of *Roman* Building, any where to be seen in *Great Britain*.

From the Arguments on the foregoing Authorities, *Anderida* must have been somewhere in *Sussex*, not in the West but East part of it, and not far from the East End of the *Downs*, near the Sea. From the Bath, Pavement, Coins, and Bricks, 'tis sure the *Romans* had once an Abode, and not a short one, at this Place near *East-Bourne*: From the large Extent of Foundations about the Place where these were discover'd; that there was a large Town or City there: From the common Height those Foundations bare under the Surface of the Ground; that the Buildings they sustain'd were effectually levell'd or raz'd: And from the Coals dug up amongst the Rubbish, 'tis evident that Part was burnt; all which Cir-

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cumstances

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<sup>1</sup> *Henr. Huntindon*, Hist. Lib. VI.

cumstances well enough agree with the Account given us of *Anderida*.

The Situation likewise of a Town here, gives reason enough to suppose, it was a Place of Importance, and whence it had its Name; no Part hereabouts being any way so convenient, for a secure Settlement; or for such a use as the *Romans* might have occasion to make of it. We are inform'd by *Cæsar*, that the Maritime Parts of *Britain* (speaking of what he saw, which was the South-East) were inhabited by People from *Belgium*; and that they call'd their Settlements by the Name of the Places from whence they came. It was the Opinion of *Tacitus* also, that <sup>2</sup> those who inhabited next to *Gaule*, came from *Gaule*. And *Bede* says, the Tradition in his Time was, that the Southern Part of the Isle was peopled <sup>3</sup> from *Bretaign*. In the Third and Seventh Books of *Cæsar's* Commentaries, mention is made of the *Andes*, a City and a People belonging to it among the *Celtae*, inhabiting on the Sea Coast. Time varying the Names of Things, near Two Hundred Years after *Cæsar*, *Ptolemy* calls the City *Anderidum*: And near 250 Years after him, when the *Notitia Imperii*, now extant, was in use, the *Classis Anderetianorum* <sup>4</sup> is register'd; and the Residence of their Admiral fix'd at *Paris*. From whence 'tis to be inferr'd, that tho' the Capital of the *Andes* might have been *Angers* near the *Loyre*, yet their Country had on the North the *British* Channel; and on the East the *Seine* for its Bounds. The *British* Coast about *East Bourn* is the nearest of any to the Mouth of the *Seine*; Therefore,  
according

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<sup>1</sup> De Bell. Gal. Lib. V. *Qui omnes, fere iis nominibus civitatum appellantur, quibus orti ex civitatibus eo pervenerunt.* <sup>2</sup> Tac. Agric. cap. xi. In universum tamen æstimanti, Gallos vicinam solum occupasse credibile est.

<sup>3</sup> Bedæ Hist. Eccl. Gent. Angl. Lib. I. cap. 1. In primis hæc insula Britones solum, a quibus nomen accepit, incolas habuit; qui de prælo Armaricano (ut fertur) Britanniam adierunt. *Aufrales* sibi partes illius vindicarunt. <sup>4</sup> Pancirol. Coam. in Notit. Imp. Cap. XC. pag. 79, 180.

according to the Usage before *Cæsar's* Time, the Name of *Anderida* there, is readily accounted for. Moreover, this Place seems most naturally seated, for giving an Appellation to the great Wood, to which it adjoin'd : For, as it self is on the Shoar, so also the *Sylva Anderida* here, came very near the Shore ; and a large part of it might be seen from the Sea before it : Indeed, on the Sea off of *Romney*, it might be discover'd ; but then the Distance was great : At all other parts of the Coast, the Sight of it from Sea, is hinder'd by Hills, or high Cliffs.

Setting aside the want of a navigable River, the Spot of Ground where this old Town stood, yields to none in the County for Importance and Pleasure : For here, like a Wedge, ends the firm Soil of the *Downs* ; Nature has shap'd it like an Equilateral Triangle, having each side half a Mile in Length : Towards the Sea, on the Southern side, 'tis fenc'd by a low Cliff, of 12, 15, and in some Places 20 Foot high ( in which Cliff is now to be seen a strong Foundation, that has acute Angles, which shews it to have been for a Fort rather than a Dwelling-House ) On the Northern side is a Morass, with a large Rivulet of very good Water. Between the West side and the *Downs* lies a small Valley, by which Advantage, there was formerly a Harbour, capable of a small Fleet ; the Banks on each side of it are an Evidence it was sunk by Industry ; but by Weeds and Gravel from the Sea, and by Mould annually added, as is observable <sup>1</sup> in Valleys, it is now so rais'd, that 'tis never flow'd but at high Spring-Tydes, when a strong Wind forceth the Waves into it. This Harbour must have been a good Security to part of the West side ; what other Works might have been to guard it, from

K k k k k k 2

the

the end of the Harbour to the Morals, cannot be said; by reason the Ground between has for many Ages been in Tillage. It is easy to imagin of what Importance a Town fortified at this Place must have been in those Ages, when the only Pass by Land from the West to the East End of the County was through it; for other there could not be, in many Miles North; unless the Lands in that Tract, which are still very owzy and tender, had been well drain'd.

As the Situation describ'd, render'd this Place strong; it is very pleasant withal; for the Ground is high enough for a good Prospect of the Low Lands adjoining, and the Country towards *Battell*; besides, it has a commanding View over that Bay, which is between *Beachy-Head* and *Hastings*. If the Use made of it by the *Romans*, was to guard the Coast, there was this Advantage belonging to it; that a Centinel on the top of *Beachy*, not Two Miles from it, in a clear Day, without turning his Body, might see the *Isle of Wight*, the Hills in *France* near *Bologn*, and the *Ness* in *Kent*; so that from the *Ness* to *Selsey* it must have been a small Sail that could escape his Eye. It was my purpose to have added a Description of *Pevensey-Castle*; together with an Account of some Remains of Antiquity, discover'd last Summer towards the West End of the County: But having been too tedious already, must defer that for the present, and subscribe my self,

*Your most humble Servant,*

*Lewes, Jan. 26.*

17<sup>16</sup>/<sub>17</sub>.

JOHN TABOR.

III. *Tractatus;*

III. *Tractatus de Curvarum Constructione & Mensura ; ubi plurimæ series Curvarum Infinitæ vel rectis mensurantur vel ad simpliciores Curvas reducuntur. Autore Colin Maclaurin, in Collegio novo Abredonensi Matheseos Professore.*

**E**Ximia Matheseos Theoriæ, ob infinitam Propositionum Universalitatem, æternam ac necessariam Veritatem, Evidentiam omni dubitatione majorem, Idearum claritatem luculentissimam, Demonstrationum elegantiam, Theorematum nexus & mutuas dependentias, pulcherrimis certè ac summis humani intellectus repertis sunt annumerandæ; inter eas vero eminent summorum hujus sæculi Philosophorum de Curvarum Longitudinibus & arcibus mensurandis ardua Theoremata. Ad hos diffusos cognitionis campos diu altè latentes tandem cruendos infinitæ scientiæ portiunculam mutuari, vix sibi temperare posset quin pronuntiaret, qui Arithmeticæ Infinitorum vires in immenso elegantissimarum Veritarum abyssu cruendo, & humani intellectus Horizontem infinite ferè extendendo, paucis præteritis annorum decadibus, amplè satis comprobatas, animo perpenderit; Hujus vero methodi ( sicut nunc aucta & exculta est ) ope, incidi in rationem mensurandi infinitas Curvarum series, quam paucissimis explicabo.

Cum in omni linea curva sit aliqua curvaturæ regularitas licet fortè implicata, secundum quam figura determinatur; ideo Geometræ varias Curvarum characteres ex Equatione Ordinarum relationem ad abscissas axis aliqujus experimente definierunt. Cum verò idem fieri possit ex consideratione Curvarum respectu unius dati centri,

into

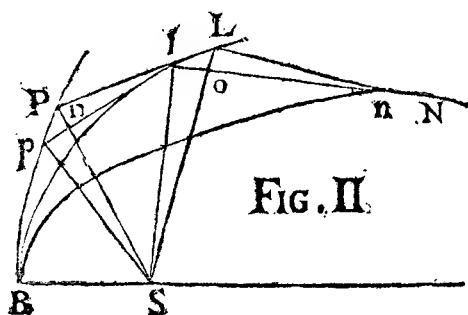


&  $l n$  perpendiculares in radios  $S L$ ,  $S l$ , sibi mutuo occurrentes in  $n$ ; & per omnia similiter definita perpendicularium concursuum puncta describatur Curva  $E N$ : ea ipsa erit Curva ex qua deduci potest  $B L$ , eadem ratione qua construximus  $D P$  ex  $B L$ . Ex  $E N$  similiter construi potest alia Curva, atque ex hac quoque parte Series infinita Curvarum construi poterit.

§ II. Curvarum verò hac ratione consideratarum simplicissimæ sunt quarum  $L l$  est ad  $L o$  in ratione potestatis alicujus Radii, ita ut, si  $a$  sit data quantitas,  $r$  denotet Radium Curvæ,  $n$  numerum quemcunque, sit  $L l$  ad  $L o$  ut  $a^n$  ad  $r^n$  æquatio earum generalis. Omnes verò hæ Apſidem habent cum  $r=a$ , quoniam in eo casu  $L l=L o$ . Ut investigem æquationem Curvæ  $D P$ , cum in  $B L$  est ut  $L l$  ad  $L o$  ita  $a^n$  ad  $r^n$ , ita  $r$  ad  $S P=\frac{r^{n+1}}{a^n}$ , ita  $\frac{n}{a^{n+1}} \times S P^{\frac{1}{n+1}}$  ad  $S P$ , ita  $a^{\frac{n}{n+1}}$  ad  $S P^{\frac{n}{n+1}}$ , ita  $P p$  ad  $p n$ . Proinde si  $i$  representet momentum Curvæ,  $j$  arcum circulearem radio descriptum à centro  $S$ , &  $r$  radium correspondentem, quæcunque sit Curva cujus Æquatio investigatur, erit Æquatio Curvæ  $B L$ ,  $i : j :: a^n : r^n$ ; Æquatio verò Curvæ  $D P$ ,  $i : j :: a^{\frac{n}{n+1}} : r^{\frac{n}{n+1}}$ . Angulus autem  $P S p$  erit ad Angulum  $L S l$  ut  $\frac{p n}{S P}$  ad  $\frac{l o}{S L}$ , sive ut  $\frac{P n}{S P}$  ad  $\frac{L o}{S L}$ , vel ( si  $S P$  dicatur  $x$  &  $S L$ ,  $r$  ) ut  $\frac{x}{x}$  ad  $\frac{\dot{r}}{r}$ , hoc est, ( ob  $x=\frac{r^{n+1}}{a^n}$  ) ut  $\frac{n+1}{r} \dot{r}$  ad  $\frac{\dot{r}}{r}$ , sive ut  $n+1$  ad  $1$ . Hinc ( *vid. Fig. II.* )  $B S P$  est ad  $B S L$  ut  $n+1$  ad  $1$ ; unde facilius absque Tangentium ope duci potest Curva  $B P$ . Si sumatur angulus  $B S P$  ad  $B S L$  in ratione  $n+1$  ad  $1$ , & in  $S P$  demittatur perpendicularis ex  $L$ , erit occurſus perpendiculi cum  $S P$ , in Curva  $B P$  prius Tangentium ope descripta.

§ III. Oſen-

§ III. Ostendimus quo pacto ex unâ series Curvarum infinita deducitur; quo verò pacto singularum longitudines ex illius & unius alterius longitudinibus datis innotescant pergo demonstrare. Cum angulus  $SPp = SLI$ ,



atque  $LSl$  fit ad  $PSp$  ut  $1$  ad  $n+1$ , erit  $Ll$  ad  $Pp$  ut  $SL$  ad  $n+1 SP$ , five (ob  $SL : SP :: Ll : lo$ ) ut  $Ll$  ad  $n+1 lo$ , ac proinde  $Pp = \frac{n+1}{1} lo$  : sed  $lo = ln - on$   
 $= ln - LN + Nn$  ; ergo  $Pp = \frac{n+1}{1} \times ln - LN + Nn$ .  
 Sed  $ln - LN$  est momentum rectæ  $LN$  normalis in  $SL$ ,  
 $Pp$  momentum Curvæ  $BP$ , &  $Nn$  momentum Curvæ  
 $BN$  : Cumque  $BP$ ,  $BN$ ,  $BL$  simul evanescant in  $B$ , e-  
 runt in ratione momentorum, adeoque  $BP = \frac{n+1}{1} \times$   
 $\frac{BN}{BL}$  vel  $-LN$ . Unde Curva  $BP$  est ad summam vel  
 differentiam Curvæ penultimæ in Serie ejusque Tangen-  
 tis ab intermedia interceptæ, ut  $n+1$  ad  $1$  ; five, si  $m$  sit  
 Index æquationis Curvæ  $BP$  ( quoniam  $m = \frac{n}{n+1}$  ) ut  $1$   
 ad  $1-m$ .

Hinc 1<sup>mo</sup> in serie Curvarum infinitâ supra descriptâ, si  
dantur Longitudines duarum proximarum, dabuntur  
longitudines omnium; quippe mensura cujusvis pendet à  
mensura penultimæ semper in serie, & proinde unum  
par





*mason de M. Roberval*, quamque *M. De la Hire* considerat ut *Conchoidem* Basis Circularis, in Actis Academiæ Parisiensis Anni 1708. Perpendiculares omnes  $LN$ , *in* concurrent in puncto  $B$ , adeoque  $BN = \infty$ : unde  $BP = \frac{BN + NL}{1 - m} = 2BL$ : Hinc Curva tota  $BPS = 2BS$ , ac lon-

ginitudo *Epicycloidis* semper dupla est chordæ arcus in circulo correspondentis. 2<sup>do</sup>. Ex *Epicycloide* describatur Curva  $B\Pi S$ , eadem ratione qua *Epicycloidem* ex Circulo descripsimus: In hoc casu  $n = \frac{1}{2}$ , &  $m = \frac{n}{n+1} = \frac{\frac{1}{2}}{\frac{1}{2}+1}$

$= \frac{1}{3}$ , ac proinde æquatio Curvæ  $B\Pi S$  erit  $\dot{x} : \dot{y} :: a^{\frac{1}{2}} : r^{\frac{1}{2}}$ .

Longitudo Curvæ erit  $\frac{BL + LP}{1 - m} = \frac{2}{3}BL + LP = \frac{2}{3}BL + LG$ ,

& proinde  $B\Pi$  est sesquiplus summæ Arcus circularis ejusque Sinus recti. Quod si sumatur  $CD = BD$ , & radio  $SD$  centro  $S$  describatur Circulus occurrens rectæ  $SP$  in  $H$ , & sit  $HK$  perpendicularis in  $BS$ ; quoniam  $DH = \frac{2}{3}BL$ , erit  $B\Pi = DH + HK$ . Hinc arcus  $B\Pi$  neque sunt rectis neque arcibus circularibus commensurabiles, differentia tamen arcuum  $B\Pi$  &  $DH$  est recta  $HK$ . In puncto  $S$  evanescit  $LG$ , adeoque  $B\Pi S = \frac{2}{3}BLS$ , unde tota Curva est sescupla semicirculi. Nulla vero pars hujus Curvæ assignabilis commensurari potest toti, nec integra Curva in data quavis ratione secabilis est, ita ut portiones rationem assignabilem habeant ad se mutuo aut ad totam. Si hæc curva in data aliqua ratione Geometricè secari posset, constaret Quadratura Circuli, nam si *e gr.* esset  $B\Pi$  ad  $B\Pi S$  ut  $1$  ad  $m$ , &  $BL$  ad  $BLS$  ut  $1$  ad  $n$ , esset  $B\Pi = \frac{B\Pi S}{m} = \frac{2BLS}{2m} = \frac{3nBL}{2m} = \frac{2}{3}BL + LG$ ,

unde esset  $BL = \frac{mLG}{n-m}$  &  $BLS = \frac{n}{n-m}LG$ . 3<sup>to</sup> Ex  $B\Pi S$ ,

construatur explicata methodo Curva  $BR$ , & quoniam  $n = \frac{1}{2}$

$n = \frac{1}{3}$  erit  $m = \frac{n}{n+1} = \frac{1}{4}$ , atque æquatio Curvæ BR erit

$\dot{s} : \dot{y} :: a^{\frac{1}{4}} : r^{\frac{1}{4}}$ . Hinc longitudo Curvæ fiet  $\frac{1}{2} 2\overline{BL} + \overline{PN}$ ,  
totalis verò Longitudo Curvæ BR  $S = \frac{8}{3}$  diametri SB.  
Si harum Curvarum Construtiones continuentur, prodibit hujusmodi series Æquationum quæ facile produci-  
tur ad libitum.

Æquatio Circuli	1. $\dot{s} : \dot{y} :: a : r$
Epicycloidis	2. $\dot{s} : \dot{y} :: a^{\frac{1}{2}} : r^{\frac{1}{2}}$
Secundi	3. $\dot{s} : \dot{y} :: a^{\frac{1}{3}} : r^{\frac{1}{3}}$
Tertii	4. $\dot{s} : \dot{y} :: a^{\frac{1}{4}} : r^{\frac{1}{4}}$
Cujusvis	$n. \dot{s} : \dot{y} :: a^{\frac{1}{n}} : r^{\frac{1}{n}}, \&c.$

Observare licet in genere, omnes quarum Indicium deno-  
minatores sunt Numeri pares, perfectæ rectificationis esse  
capaces; cumque quævis sit ad penultimam ut 1 ad  $1-m$ ,  
perpendenti manifestum erit Curvæ cujusvis longitudi-  
nem fore  $= \frac{1}{1-m} \times \frac{1-2m}{1-3m} \times \frac{1-4m}{1-5m} \times \frac{1-6m}{1-7m}, \&c. \times SB$

continuando seriem donec ad nihilum reducatur Fractio.  
Quod si Indicis denominator sit Numerus impar, Curvæ  
erunt perfectæ rectificationis incapaces, & earum arcus  
quicunque erunt sibi mutuo, ipsis totis rectis quibusvis  
& arcubus Circularibus incommensurabiles: exprimi verò  
possunt omnes arcubus circularibus & rectis: At Cur-  
væ cujusvis totalis Longitudo erit ad Semicirculum ut

$\frac{1}{1-m} \times \frac{1-2m}{1-3m} \times \frac{1-4m}{1-5m}, \&c. \text{ ad unitatem. Denique si } \text{Areola à Corpore in harum quavis revolvente sumatur con-}$

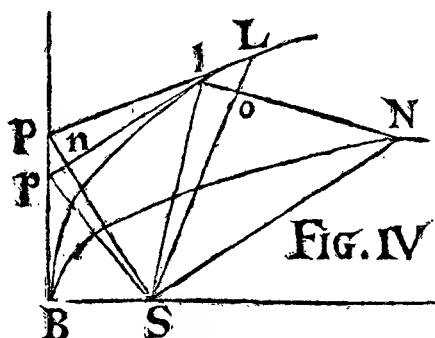
stans, hoc est si  $r \dot{y} = 1$ , subtensâ anguli contactus, cui  
semper ( ob datum datâ areâ tempus ) proportionalis est  
*Vis Centripeta* tendens ad S, erit reciproce ut potestas di-  
stantiæ cujus Index est  $2m+3$ ; atque hoc est non con-

L l l l l l 2

temnendum

temnendum harum Curvarum privilegium, quod in iis omnibus Vis centripeta tendens ad S sit ut aliqua reciproca distantiae dignitas, quæ simplicissima est, & utilissima in Naturæ indagine, Virium Centripetarum lex.

§. V. Curvarum quarum  $s : y :: a^n : r^n$  proxime consideranda venit ( quæ Curva quidem improprie dicitur ) ipsa Linea recta, existente S extra rectam. In hac linea, ob similia triangula P p n, P B S erit ( si  $BS = a$  &  $SP = r$  )  $s : y :: r : a$ . Ex linea recta methodo directâ



nihil nisi punctum B construi potest, Methodo vero inversâ, perpendicularium nimirum P L, p l concursu, construi potest Curva, cujus Index ( si  $m$  sit Index Curvæ B P ) æqualis erit  $\frac{m}{1-m}$ ; nam si Index Curvæ B L sit  $n$ ,

erit  $m = \frac{n}{n+1}$ , ac proinde  $n = \frac{m}{1-m}$ . Unde in hoc casu,

cum  $m = -1$  erit  $n = \frac{-1}{2}$ , & æquatio Curvæ B L erit

$s : y :: r^{\frac{1}{2}} : a^{\frac{1}{2}}$ , quæ æquatio est Parabolæ ad Focum. Ex hac construe aliam, constituendo angulum L S N = L S B & erigendo L N normalem in S L occurrentem ipsi S N in N. Quoniam vero  $m = \frac{-1}{2}$  erit  $n = \frac{-1}{3}$ , & æquatio Cur-

væ  $s : y :: r^{\frac{1}{3}} : a^{\frac{1}{3}}$  & B P =  $\frac{BN - LN}{1 - m} = \frac{1}{2} BN - LN$ , ergo

B N =

$BN=2BP+LN$ ; proinde hæc Curva est rectificabilis. Si Series continuetur, prodibunt ut prius æquationes in hoc ordine.

Æquatio Rectæ	$\dot{s} : \dot{y} :: r : a$
Parabolæ	$\dot{s} : \dot{y} :: r^{\frac{1}{2}} : a^{\frac{1}{2}}$
Secundæ	$\dot{s} : \dot{y} :: r^{\frac{1}{3}} : a^{\frac{1}{3}}$
Tertiæ	$\dot{s} : \dot{y} :: r^{\frac{1}{4}} : a^{\frac{1}{4}}$
Cujusvis	$\dot{s} : \dot{y} :: r^{\frac{1}{n}} : a^{\frac{1}{n}}$

In hac Serie primæ sunt Recta & Parabola, unde paret dimidiam hujus similiter ac prioris Seriei esse rectis mensurabilem: alia vero dimidia pars in rectis & arcubus Parabolicis exhiberi potest. In his omnibus Vis centripeta ad S est reciproce ut potestas distantix cujus Index  $3-2m$ , ac proinde semper inter duplicatam & triplicatam rationem distantix reciproce.

§ VI. Æquatio-Hyperbolæ æquilateræ ad centrum est  $\dot{s} : \dot{y} :: r^2 : a^2$ , ex qua deducitur methodo directa Series hujusmodi,

1.  $\dot{s} : \dot{y} :: r^2 : a^2$
2.  $\dot{s} : \dot{y} :: a^2 : r^2$
3.  $\dot{s} : \dot{y} :: a^{\frac{2}{3}} : r^{\frac{2}{3}}$
4.  $\dot{s} : \dot{y} :: a^{\frac{2}{5}} : r^{\frac{2}{5}}$
5.  $\dot{s} : \dot{y} :: \frac{a^{2n}}{2n-1} : \frac{r^{2n}}{2n-1}$

Ex his Curvæ, quarum Indicium denominatores sunt in progressionem  $-1, 3, 7, 11, \&c.$  exhiberi possunt in rectis & arcubus Hyperbolicis; reliquæ verò in rectis & arcubus Curvæ cujus æquatio ad axem SB ( si  $x$  sit abscissa,  $y$  verò Ordinata ) est  $\overline{xx+yy}^2 = a^2x^2 - a^2y^2$ , quæque constituitur ( *vid. Fig. III.* ) bisecando angulum BSL & sumendo.

sumendo SN mediam proportionalem inter SB & SL.

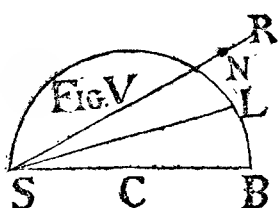
Curvæ quæ ex Hyperbola methodo inversa construi possunt progrediuntur in hac Serie,

$$\begin{aligned} \text{Hyperbolæ 1. } & s : y :: r^2 : a^2 \\ & 2. \quad s : y :: r^{\frac{2}{3}} : a^{\frac{2}{3}} \\ & 3. \quad s : y :: r^{\frac{2}{5}} : a^{\frac{2}{5}}, \text{ \&c.} \end{aligned}$$

Ubi Curvæ quarum Indicium denominatores sunt in progressionem 1, 5, 9, 13, &c. exprimi possunt in rectis & arcubus Hyperbolicis; reliquæ verò in rectis & arcubus Curvæ modo explicatæ.

Si aliæ Curvæ desiderentur quæ alias exhiberent Series, id facillime fieri potest ope vel Circuli vel Rectæ:

quippe ex earum aliqua omnes, in quibus  $s : y :: a^n : r^n$ ,



construi possunt, sumendo, si ope Circuli Problema sit solvendum, BSR ad BSL ut 1 ad  $n$ ,

& SN in ipsa SR =  $a^{\frac{n-1}{n}} \times SL^{\frac{1}{n}}$ ;

quippe Curvæ per omnia pun-

cta N ductæ æquatio erit  $s : y :: a^n : r^n$ . Similiter ope Rectæ construi possunt quarum æquatio est  $s : y :: r^n : a^n$ .

Duas exhibuimus Series infinitas Curvarum rectis commensurabilium; aliam arcubus circularibus, aliam Parabolicis, aliam Hyperbolicis una cum rectis mensurabiles demonstravimus: eæ vero ad rectarum mensuram arte sola infinita reduci posse videntur, sicut æquatione sola infinita in rectis exprimuntur.

*Hæc Cl. Author brevitati studens paucis tradit, illum autem plenius rem pro dignitate ejus illustraturum speramus.*

#### IV. Remarks

IV. *Remarks on a Fragment of an old Roman Inscription lately found in the North of England, and transcribed by the Curious and Learned Dr. James Jurin, M. D. and Reg. Soc. S.*

OUR worthy Member, Dr. *Jurin*, having resided for some time at *Newcastle upon Tyne*, had the Curiosity to travel the Country between that and *Carlisle*, in order to observe what might occur worth notice in the Remains of the Ruins of the famous *Piſts-Wall*, built by the *Romans* to secure themselves, against the Incursions of the Natives of that part of *Britain* they cared not to conquer. In this Perambulation, besides many other valuable Observations which in time he may be prevail'd with to bestow on the Publick, Dr. *Jurin* saw and transcrib'd no less than Twenty *Roman Inscriptions*, some of which we had formerly receiv'd from others, but many of them wholly new; among them the following, which, tho' broken and in great part illegible, suffices to fix the Name of one of the Ancient Nations of *Britain*, that has hitherto been greatly miscall'd, 'Tis thus,

CIVITATE CAT  
VVILLAVA'  
ORVM L. OL S  
C D 10

and is to be seen on the *Wall*, about two Miles West from *Legercros-Abby*, near the Confines of our two Northernmost Counties.

Here

Here 'tis observable, that the last A of the second Line has a Mark that follows it, not unlike to the last Stroak of an N; and if instead of A' we put N, we shall read it CIVITATE CATVVILLAVNORVM, which we cannot doubt to have been the true Name of that People which *Dion. Cassius*, *Lib. LX.* calls Κατελλανοί, and *Ptolomy*, in his *Geography*, *Lib. II. cap. 3.* more falsely, Κατενυχανοί; the first λ by producing the transverse Stroak having been mistaken for χ. This Nation appears by *Dion* to have been more potent than their Neighbours the *Dobuni* (whom he calls *Boduni*). and had, according to *Ptolomy*, *Verolanium* for their Capital, which 'tis most probable, was the *Cassivellauni oppidum* of *Cæsar*. So that it should seem *Cassivellaunus* King of these *Catuvillauni* when *Cæsar* invaded *Britain*, either gave his Name to his People, or took theirs. But he was no doubt the most potent Prince at that time in *Britain*, since by common Consent of the rest, he was made General of their united Forces, in defence of their Country's Cause against the *Romans*.

## F I N I S.

ERRATUM, N<sup>o</sup> 355.

Page 770. lin. 22. for *Maii* 31. lege *Martii* 31.

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# PHILOSOPHICAL TRANSACTIONS.

For the Months *July, August, and Septemb.* 1718.

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I. Cometæ

I. *Cometæ Berolini nuper visi observationes, ut & Eclipses Solaris Feb. 19<sup>no</sup> mane, Noribergæ & Berolini habitæ, è Novis Litterariis Berolinensibus, hoc anno primum edi cœptis, desumptæ.*

**C**L. *Christfridus Kirchius*, motus Corporum cœlestium, ut munere sibi à Societate Scientiarum Regia (*Berolini*) demandato recte fungeretur, sedulò observans, a. d. XV. Kal. Febr. (*Jan 18. st. n.*) anni præsentis, vesperi dimidiâ Septimâ, versus Septentriones fortuitò Cometam conspexit. Vicinus erat ad dextram (stellarum)  $\gamma$  &  $\beta$  *Bayeri* in *Ursa minore*, nudoque oculo longè distinctius apparebat, quam  $\beta$  *Ursæ minoris*, licet ea insignis sit Stella secundæ magnitudinis, cum longè pallidior quidem majore tamen diametro, atque satis clara luce maxime circa centrum, conspiceretur. Per Tubum visus lucidam rotundamque referebat nubeculam; Caudæ autem nullum observari potuit vestigium, neque Nucleus dignosci. Moru celerrimo ab hora VII. ad XI. processit, gradusque quatuor cum dimidio absolvit, ut ex observationibus colligitur.

Die 19<sup>no</sup> & 20<sup>mo</sup> *Januarii* cœlum nubibus fuit obductum. Die verò 21<sup>mo</sup> Cometa longè recesserat à loco suo nupero, atque in *Cassiopea* deprehendebatur, ubi cum stellis  $\epsilon$  &  $\delta$  triangulum conficiebat (*an aquicrura?*) scil. Hora 5<sup>h</sup> 45' in 17° 34' 8", sub latitudine Boreali 49° 54' hærebat: Deinde 9<sup>h</sup> 15', in 16° 38' 8" sub Lat. Bor. 49° 2' conspiciebatur. Cæterum multum decreverat, atque à celeritate sua remiserat; præterquam enim quod pallidior quam ante apparebat, stellas etiam quartæ dignitatis magnitudine haud superare nudo oculo

lo conspectus videbatur, inque orbita sua, quatuor cum dimidia horis, non ultra sesquigradum processerat: Tubi autem beneficio diameter ejus 7 min. inveniebatur.

Jan. 23. hora IV. mat Cometa cum  $\delta$  &  $\phi$  Cassiopeæ triangulum æquicrurum efficiebat, cum ab utraque  $2^{\circ}$   $41\frac{1}{2}$  abesset. Hoc mane duarum horarum spatio vix dimidium gradum absolvit; hora decima vespertina cum  $\delta$  Cassiopeæ &  $\phi$  Persei in linea recta cernebatur, atque à priori  $3^{\circ} 38'$ , à posteriori  $3^{\circ} 9'$  distabat. Diameter ejus erat 5 min. nudoque oculo conspectus stellam quintæ magnitudinis referebat.

Die 24<sup>to</sup> Jan. hora VI. mat. nondum attigerat  $\phi$  Persei, sed cum  $\nu$  &  $\gamma$  ejusdem Asterismi triangulum æquicrurum sistebat, & ab utraque non planè  $3\frac{1}{2}$  grad. aberat. Plura ex observationibus docebit Astrophilos Vir accuratissimus, in pleniori quam parat hujus Cometæ Historia.

*Hactenus Nova Litteraria dicta pag. 43, 44. ubi desiderantur Observationes Diei 18<sup>ve</sup>, cum Cometa velocissime motus terræ proximus erat, unde certius de Via ejus tam vera quam apparente judicium ferre possemus. Manifestum autem est eum Polo Æquatoris Boreo vicinissimum die Januarii 19<sup>no</sup> transisse. Quod si cui libeat has Observationes ad examen revocare, calculoque accurato subjicere; in illius gratiam, loca Stellarum fixarum, quarum hic fit mentio, ex Catalogo Britannico excerpta, subnectuntur: Unde etiam patebit nonnulla in hac motus Cometa descriptione haud rite se habere; qua tamen à Cl. Kirchio corrigi, in pleniori ejus quam promisit historia, spes est.*

Stellarum

*Stellarum fixarum Loca ineunte Anno 1718.*

BAYERO		Long.			Lat. Bor.			
		°	'	"	°	'	"	
<i>Ursa minoris</i>	$\beta$	22	9	18	0	72	58	10
	$\gamma$	22	17	35	15	75	13	15
<i>Cassiopeæ</i>	$\delta$	28	14	00	35	46	23	25
	$\epsilon$	28	20	50	8	47	31	50
	$\phi$	28	11	36	35	45	4	5
<i>Persei</i>	$\nu$	28	8	32	0	35	23	45
	$\phi$	28	10	41	35	36	49	15
	$g$	28	12	15	20	36	18	37

*Ex iisdem Novis etiam obtinuimus duplicem observationem Eclipsæ exiguæ Solaris, currentis anni Feb. 19<sup>to</sup> ft. ver. mane celebratæ; alteram Noribergæ à Cl. D. Wurtzelbau, alteram à præfato D. Kirchio Berolini habitam.*

*Noribergæ autem Sol ortus est aliquantulum deficiens in limbo superiore, qui quidem defectus ad tres plene digitos accrevit; Desit Eclipsis 8<sup>h</sup> 8' 48" circa 60 grad. à Vertice Solis ad Sinistras. Berolini vero Sol statim ab ortu cæpit deficere, Hora scil. 6 49' vel 49<sup>½</sup>'. Circa medium Eclipsæ, nempe 7<sup>h</sup> 35', erant Partes lucide in Sole residuæ 24' 40'', unde digitus obscurati 2<sup>dig.</sup> 50'. Finis autem incidit in 8<sup>h</sup> 28' 10''. Qui plura de his cupit, adeat Nova ipsa Berolini edita.*

H. *A Discourse occasion'd by an Inscription found, about Three Tears ago, at Langcheſter in the Biſhoprick of Durham, and communicated to the Royal Society from Dr. Hunter by Dr. Woodward, as it is printed in the Philoſophical Tranſactions, N<sup>o</sup> 354. By Roger Gale, Eſq; R. S. S.*

**D**R. Hunter, who communicated this Inſcription, having only given us his Conjectures as to the firſt fortifying the Place where it was found, and the Time of its Repair after it had been deſtroÿ'd, but ſaid nothing relating to the Explanation of the Inſcription itſelf, tho' extremely curious; it will not, I hope, be taken amiſs, if I offer ſome Thoughts that occurr'd to me at firſt ſight of it, and afterwards induc'd me to put together what follows upon that Subject. I ſhall not in the leaſt diſpute or call in queſtion the Time of its Foundation, as fix'd by the Doctor, but begin with the Place where it was diſcover'd, namely *Langcheſter* or *Lancaſter*, in the Biſhoprick of *Durham*, which I am, <sup>1</sup> with him, fully perſuaded was the *Longovicus*, where the *Notitia Imperii* places the <sup>2</sup> *Numerus Longovicariorum*.

This place is ſeated upon a great Military Way, about 12 Miles diſtance from *Bincheſter*, and 7 from *Ebcheſter*, the one the *Vinovia*, and the other the *Vindomora* of *Antoninus*, as the Correſpondence of the Numbers may evince; *Bincheſter* being 19 Roman Miles from *Ebcheſter*, as that is 9 from *Corbridge*, the exact Numbers the *Itinerary* gives us between *Vinovia*, *Vindomora*, and *Corſtopitum*. What is very ſtrange is, that the *Itinerary*, which muſt go upon the great Road directly thro' this

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N n n n n

Town

<sup>1</sup> *Philoph. Tranſ.* N<sup>o</sup> 266. p. 657.

<sup>2</sup> *Not. Imp.* fol. 176.

Town of *Longovicus* betwixt *Vindomora* and *Vinovia*, takes not the least Notice of it, but measures the Way at the whole Length and Number of Miles, from the first to the latter of those Stations. If *Longovicus* was founded, as Dr. Hunter supposes<sup>3</sup>, so early as the Time of *Julius Agricola*, and if that *Itinerary* was composed by any of the Emperors that bore the Name of *Antoninus*, this Station might have been destroyed or deserted during the Wars with the *Britains* and not being repaired till the Reign of *Gordian III.* was pass'd over by the Author of the *Itinerary*, as a Camp not then in being, or of no use to the *Roman* Armies; and this would be no weak Argument for the Antiquity of that Work: And perhaps some Parts of it may have been described as early as the Reigns of those Emperors, or earlier, and such Names of more modern Places as are found in it, may have been afterwards added as Occasion required. As a farther Confirmation of this Conjecture, I beg leave to observe, that this Place, after it was repaired by *Gordian*, subsisted even to the Ruine of the *Roman* Empire in *Britain*, as is evident by the Mention of it in the *Notitia Imperii*; so that had this Journey which carries us from *Vindomora* to *Vinovia* been compos'd after the Reign of *Gordian*, it would be very hard to account for the Omission of this remarkable Station and Town, as it appears to have been from this, and many other Inscriptions found there.

Having this Opportunity of doing it I am unwilling to let it slip without rectifying a Mistake in the *Essay towards the Recovery of the Roman Highways thro' Britain*, printed in the 6th Volume of Mr. Hearne's *Itinerary of Leland*<sup>5</sup>, which having brought the *Erminstreet* (not the *Watlingstreet*, as Dr. Hunter and the Country call it) a little beyond *Cattarick* in *Yorkshire*, divides it there into two Branches,

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*Pb. Trans.* N<sup>o</sup> 354. p. 702. <sup>4</sup> *Iter. I. a Limite Prator. usq;* <sup>5</sup> P. III, III.

Branches, tracing one of them to *Tinmouth*, and the other to *arlsf*: but omits the main Stemm of it, that runs almost directly Northward to *Piercebridge*, so to *Denton*, *Houghton*, *Binchester*, *Langcheſter*, *Ebcheſter*, *Corbridge*, and through the Heart of *Northumberland* into *Scotland*, about a Mile and a half to the Weſt of *Bornick*. It is in ſeveral places very intire and fair, eſpecially between *Corbridge* and *Bincheſter*, the Ridge of it there being for the moſt part two Yards in Height above the Level of the Soil, no leſs than Eight Yards broad, and all pav'd with Stones, that are as even as if new laid: as I am inform'd by the ingenious Mr. *Warburton*, who has often view'd it, and to whom we are oblig'd for the moſt accurate and uſeful Map of the County of *Northumberland* that was ever yet publiſh'd. This Digreſſion, if it may be ſo call'd, I hope will be excus'd, ſince it not only ſets right an Error, but acquaints you with a noble *Roman Way*, ſcarcely yet known or obſerv'd by any body.

Having fix'd the Seat of this *Longovicus*, where the Inſcription was found, let us conſider next what ſort of a Place it was; and upon due Enquiry it will appear to have been one of the moſt ancient and eminent Stations the *Romans* were poſſeſs'd of in theſe Parts. As to its Antiquity, Dr. *Hunter* has made it probable, that we ought to look for it as high as *Julius Agricola's* commanding under *Domitian*, in this Iſland: As to its Eminency, the Inſcription that came laſt from him to the Society, as well as ſeveral others found there, is an undeniable Evidence of its being a Place of great Conſideration; but nothing can put that more out of Diſpute than the firſt which was ſome Years ago tranſmitted by the ſame Hand<sup>6</sup>, which therefore I beg leave to intert here with that which came laſt from him, and the rather becauſe little or nothing has ever been ſaid upon it, and that they will give great Light one to the other.

N n n n n 2

IMP

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<sup>6</sup> *Phil. Tranſ.* N<sup>o</sup> 266.

IMP·CÆS·M·NT·G<sup>o</sup>RDIA  
N<sup>v</sup>S·P·F·AVG·B<sup>A</sup>LNE<sup>v</sup>M·C<sup>v</sup>M  
B<sup>A</sup>S<sup>I</sup>L<sup>I</sup>C<sup>A</sup>·A·L<sup>o</sup>·IN<sup>s</sup>TRVX<sup>I</sup>T  
PRE<sup>g</sup>NE<sup>v</sup>CLAN<sup>v</sup>M·LE<sup>g</sup>·AVG  
PR·PR·GR<sup>v</sup>NT<sup>E</sup>·M·AVR  
QVIRINO PRE<sup>o</sup>HILGR

## II.

IMP CÆSAR·M·ANT<sup>o</sup>N<sup>I</sup>VS  
G<sup>o</sup>·RDIANVS·P·F·AVG·  
PRINCIPIA·ET·ARMAMEN  
TARIA·CON<sup>L</sup>PSA·RE<sup>s</sup>IT<sup>v</sup>  
IT·PER·MEGE<sup>I</sup>VM·FVSC<sup>o</sup>M·LEG  
AVG·PR·PR·GRANTE·MAVR  
QVIRINO·PR·CH·ILGOR·



The Stone whereon the first is cut has been broke in two, whereby some of the Letters are defaced, however, it may be very well read as follows; the Letters PRE in the fourth Line I take to be a Mistake of the Workman, having seen several Copies, where they are so transcribed; that they should be PER is evident from the fifth Line of the second Inscription.

- I. *Imperator Caesar Marcus Antonius Gordianus  
Pius Felix Augustus Balneum cum  
Basilica à solo instruxit  
Per Cnctum Lucilianum Legatum Augustalem  
Propratorem Curante Marco Aurelio  
Quirino Praefecto cohortis primæ Longovicariorum; or  
rather, Legionis Gordianæ.*

The second can be read only after the following manner.

- II. *Imperator Caesar Marcus Antonius  
Gordianus Pius Felix Augustus  
Principia & Armamentaria  
Conlapsa restituit  
Per Macilium Fuscum Legatum  
Augustalem Propratorem curante Marco Aurelio  
Quirino Praefecto Cohortis primæ Legionis Gordianæ.*

From these Two Inscriptions compar'd together, it will be apparent that they were not only erected under the same Emperor, but by the Care of the very same Person *Aurelius Quirinus*, tho' not in the same Year. The Emperor can be no other than *Gordianus* the youngest, or third of that Name; the two former having been slain so very soon after they had assumed the Purple, that it is improbable they should have gi-

ven any Orders or Commands for the erecting of new, and repairing of antient buildings, in so remote a Province as *Britain* was from *Africa*, where they were murder'd after a short joint Reign of scarce seven Weeks.

Dr. *Hunter* tells us, that that which was first discover'd ( and which I shall therefore always distinguish by the Name of the first ) was dug up about a Hundred Yards East from a great Square, which had been fortified with a thick, strong Wall, faced with hewen Stone, within which, and without, especially towards the East, are nothing but ruinous Heaps of Stone, and thinks the Lodging of the Garison only to have been included within those Walls. His Conjecture is very much confirmed by the <sup>2</sup> Account he gives us of the finding the last Inscription within that square Inclosure ; so that there seems to have been at this *Longovicus* a large Town, and one of those Camps call'd *Castra stativa*, where the Legions lay in Quarters during the time of Peace and Quiet.

The first Inscription tells us, that the Emperor *Gordian* built the *Balneum* and *Basilica* from the Ground, à Solo ; whereas, by the second he appears to have been only the Repairer of the *Principia* and *Armamentaria*. Perhaps therefore here might be no Town, till the *Romans* thought fit to repair their old deserted Camp at this Place, and then the Emperor might also build the *Bath* and Palace for the Residence of the *Proprator*, when in these Parts of *Britain* ; the Word *Basilica* importing both a Palace, and an Edifice for hearing of Causes, and transacting all publick Affairs. As this eminent Building was erected by the Emperor's Command, it is an undeniable Argument of the Splendor of this Town, as are the great Heaps of Rubbish, and Ruines, where  
this

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<sup>1</sup> *Phil. Transf.* N<sup>o</sup> 266. p. 658.

<sup>2</sup> *Phil. Transf.* N<sup>o</sup> 354.

this Inscription was found, of its Largeness and Extent

The second equally puts the being of the *Castrum flativum* out of dispute, when it acquaints us with the Re-building of the *Armamentaria* and *Principia* there, that is the *Arcenal* and *Quarters* either of the Legionary Soldier, that were call'd the *Principes*, or the place where the Eagles and other military Ensigns were kept. It is probable they did not belong to one particular Legion, but to several, as they had occasion to be employ'd here; <sup>1</sup> tho the *Legio sexta Victrix* seems to have the best Title to them, as being constantly quarter'd in the North; whereas, the <sup>2</sup> *Legio Secunda*, and <sup>3</sup> *Vicesima* were generally garrison'd, the first at *Caerleon* in *Wales* and *Richburrow* in *Kent*, and the other at and about *Chester*; so that the <sup>4</sup> Monuments they have left in the North were erected by them, when the Wars, and other Works, as particularly the *Wall* carry'd cross the Island, call'd them thither; which being finish'd, they returned home to their more Southern Quarters, and continu'd in them till commanded Abroad upon new Services. I will not pretend to determin when these *Armamentaria* and *Principia* first fell to ruin; perhaps it might be when *Hudrian*, *Lollius Urbicus* and *Severus* had carried their Conquests farther into the Enemy's Country, and having built those famous *Wall*, the Relicks of which we still see in the Shire of *Sterling* in *Scotland*, and in *Northumberland* and *Cumbe land* in *England*, that this Camp might be thought useless, the *Roman Forces* being drawn nearer to, and quarter'd upon the Frontiers; and so this Fortrefs abandoned and suffer'd to fall into decay, as the Word *conlapsa* implies: and not that it was

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<sup>1</sup> *Ptol. Leg. VI. Niceph. Ebor locat.*    <sup>2</sup> *Anton. Itin. XII. Not Imp.*  
<sup>3</sup> *Anton. Itin. II.*    <sup>4</sup> *Camd. p. 835, 920. Phil. Transj. N° 269*

was destroy'd by any Fire, War, or other Enemy than Age and Neglect.

Tho' the Word *conlapsa* is wrote here with an *N*, there can be no doubt but the Pronunciation of it was as we usually find it spelt, *collapsa*; a certain Argument of the Letter *N*'s being silent in the middle of a Word, before two Consonants, especially *NS*, and *NT*, when the *T* was pronounced like an *S*. To omit what <sup>1</sup> *Quintilian* says to this purpose, it is confirm'd by the Absence of that Letter in numberless Inscriptions in *Gruter*, *Reinesius*, &c. and no wonder, since the Workmen in those Days, as well as ours, usually wrote as they spoke their Words. I shall not trouble you with Quotations of any of them to this end, but as a Proof of what I say, only assure you from ocular Inspection and a most accurate Examination, that there is no transverse Line over the Letters *ES* belonging to the Word *FABRICESIS* in the Inscription of *IVL. VITALI* at *Bath*, whatever has been affirm'd to the contrary, but that the Letter *N* is totally omitted there. You will also pardon my Endeavours, before I leave this Subject, to explain a short Inscription belonging to some of our Countrymen, tho' found at *Amerbach* in *Germany* <sup>2</sup>, since it will be a new Proof of the foregoing Assertion.

### III.

NYMPHIS ♢	<i>Nymphis.</i>
N ♢ BRITTON	<i>Numerus Brittonum</i>
TRIPVTIEN	<i>Triputiensis, or —enus</i>
SVB CVRA ♢	<i>Sub cura</i>
M ♢ VLPI	<i>Marci Ulpii</i>
MALCHI ♢	<i>Malchi</i>
▷ LEG XXII	<i>Centurionis Leg. 22.</i>
PR ♢ P ♢ F ♢	<i>Primigeniæ, Piæ, Felicis.</i>

There

<sup>1</sup> *Quintil. Instit. Lib. I. c. 7.*

<sup>2</sup> *Gruter. p. xciii.*

There is no Difficulty but in the Word TRIPVTIEN, and that will presently vanish if you insert the Letter N, and read it TRIPVNT, *i. e.* *Tripontienus* or *Tripontiensis*, the Mutation of the O and V being so frequent, that no body is ignorant of it. This will bring you to *Tripontium*<sup>1</sup> or *Dombridge* in *Northamptonshire*; tho' that excellent Antiquary Dr. *Battely*<sup>2</sup>, in his *Antiquitates Rutupinæ*, would read it RIPVTIEN, and fix'd the Place whence this *Numerus* took its Appellation at *Richburrow* in *Kent*.

But to return where we left the Camp at *Longovicus*, it will be as difficult to assign a Reason for its being repaired, as it was for its being deserted; unless that the *Proprators* might judge it advisable about the Time of *Gordian III.* to fix their Residence there, and consequently refortify the old Camp for their State and Security. And that it was not refortify'd upon any sudden Emergency, but for Time and Duration, is evident both from the strong Stone-Works that encompass'd it, and a Body of Forces lying here, even at the Expiration of the *Roman* Empire and Authority in this Island, which from its Continuance in the same Station, had got the Name of the *Longovicarii*<sup>3</sup>.

The Person that under the Emperor gave Direction for these Repairs, was *Macilius Fuscus*: As *Macilius* is a Diminutive of *Macius*, it is not unlikely that he was the Son of *Macius Fuscus*, who was Consul with *Turpilinus Dexter*, A. D. 225. in the Reign of *Alexander Severus*: By this Inscription it appears that this *Macilius* was the Emperor *Gordian's* Lieutenant here and *Proprator*; For tho' in *Phil. Transact.* N<sup>o</sup> 354, by the Inadvertency of the Engraver, we read only PR. instead of PR. PR; it is right in the Original, and in the Trans-

O o o o o o

script

<sup>1</sup> *Antonin. Itin.* VI,

<sup>2</sup> p. 21.

<sup>3</sup> *Notit. Imp.* fol. 176. b.

script sent up by *Dr. Hunter*, and accordingly in *pag.* 825. the Fault is amended. And as the Name of *Fuscus* stands in the same Place in the second as that of *Lucilianus* does in the first, and with the same Adjuncts both before and after, we may fairly conclude he was either his Predecessor or Successor, but which, it is impossible to determin.

And here, perhaps, it may not be amiss to remark, we never meet with a *Legatus Augustalis* in any Inscription in this Island, without the joint Title of *Proprator*; and <sup>1</sup> *Tacitus* himself either makes them the same Office, or at least unites them in the same Person, when he tells us, *In Britannia P. Ostorium Propraetorem turbide res excipere*; and having presently after related the manner of the Fight with the *Iceni*, styles him *Legatus, Quam pugnam filius Legati, M. Ostorius, servati civis decus meruit* <sup>2</sup>; and a little after he gives both the same Titles to *A. Didius* the Successor of *Ostorius*.

We are indebted therefore to these two Monuments, not only for the Account they have preserved of the *Roman Arms* and Magnificence at *Longovicus*, but for the indisputable Records of the Names of two *Legates* and *Proprators* of *Britain*, that would otherwise have been buried in Oblivion, *viz.* *Cneius Lucilianus* and *Maecilius Fuscus*: For from *Virius Lupus* (who was *Propraetor* and *Legate* here about the Year 208, under *Severus*, and just before that Emperor's coming into this Island repaired a Bath burnt down at *Lavatrae*, or *Bowes* <sup>3</sup>, in *Yorkshire*) we have no where extant the Name of one of those Officers, till we come to *Nonnius Philippus*, whom I take to have succeeded the last of these; the <sup>4</sup> Stone which was found at *Old Carlisle*  
in

<sup>1</sup> *Tac. Lib. Ann. xlii. c. 32.*  
Edit. 1695.

<sup>2</sup> *Ibid. c. 37.*

<sup>3</sup> *Camd. p. 762.*

<sup>4</sup> *Camd. Britan. p. 830.*

in *Cumberland*, and has preserv'd his Memory, setting forth that he was *Legate* and *Proprator* when *Atticus* and *Pratextatus* were *Consuls*, which was *A. D.* 242. the very Year that our *Gordian* went upon his *Perſian* Expedition, from which he never return'd. And as that Emperor left *Nonnius Philippus* in that Poſt, when he march'd into the Eaſt, where he was murder'd about two Years after, it is highly probable that he was the laſt *Proprator* of his appointing, and conſequently, that *Macilius Fufcus* was his Predeceſſor, and the Repairs begun at *Longovicus* before the Year 243<sup>1</sup>. I would not have troubled you with this Inſcription, but that it is faultily tranſcribed in *Camden*, and that I ſhall have occaſion by-and-by to refer to it again, upon a material Point, which therefore I hope will plead my Pardon.

IV.

I. O. M.

PRO. SALVTE. IMPERATORIS  
M. ANTONI. GORDIANI. P. F.  
INVICTI. AVG. ET. SABINAE. FVR  
IE. TRANQVILE. CONIVGI. EIVS. TO  
TAQVE. DOMV. DIVIN. EORVM. A  
LA. AVG. GORDIA. OB VIRTVTEM  
APPELLAT. POSVIT. CUI. PRAEEST  
AIMILIVS. CRISPINVS. PREF  
EQQ. NATVS. IN. PRO. AFRICA DE  
TVSDRO. SVB. CVR. NONNII. PHI  
LIPI. LEG. AVG. PROPRETO.  
ATTICO. ET. PRETEXTATO COSS.

Oooooo 2

The

The Person who had the Care of these Repairs both in Town and Camp, was *Marcus Aurelius Quirinus*, *Præfect* or *Commander* of a Company of Foot; another Argument for the Proprietors *Lucilianus* and *Fuscus* succeeding immediately one the other, he serving in the same Post under both. I must observe however, that altho' the two first Inscriptions have been cut very near the same time, and by the same Hand, as appears by the Form of the Letters, and Manner of the Abbreviations in each of them, yet the Office that this *Quirinus* bore is something differently express'd in the first from what it is in the second, if they have been accurately transcribed; the First shewing, after *QVIRINO* the Letters *PRE. CH. I. L. G. R.* which, before I had seen the Latter, I was induced to read *Præfecto Cohortis primæ Longovicariorum*, the ' *Notitia Imperii* placing the *Præfectus numeri Longovicariorum Longovico*. That *Numerus* and *Cohors* were the same thing, <sup>2</sup> *Pancirollus*, in his Notes upon that Book, quotes *St. Chrysostome* to prove, and some others, *Cohors erat qui vocatur Numerus*; but I rather take it to be an indefinite Number of Men, which might comprize several Companies, independent of any Legion. <sup>3</sup> *Vegetius*, speaking of the *Legati Imperatoris*, says, *in quorum locum nunc illustres viros constat Magistros Militum substitutos, à quibus non tantum binæ Legiones, sed plures Numeri gubernantur*; by which it is plain, the *Numeri* were no *Legionary Cohorts*. Neither was the Name so modern as from the *Notitia Imperii* and *Chrysostome* it might appear to be; for we meet with a <sup>4</sup> *Numerus Britonum* upon an Altar found in *Transylvania*, dedicated to the *Nymphs*, when the Emperor *Commodus* and *Glabrio* were Consuls, *A. D.* 186. And <sup>5</sup> another *Numerus* upon an Altar erected to *Hercules* for the Prosperity  
of

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<sup>1</sup> fol. 166. b    <sup>2</sup> fol. 161. b    <sup>3</sup> Lib. II. c. 9.    <sup>4</sup> *Gruter.* p. 94. 2.    <sup>5</sup> *id.* 46. 9.



of *Septimius Severus*, when *Lateranus* and *Rufinus* were Consuls, *A. D.* 197: But after I had review'd the Letters at the end of the second Inscription, which are plainly transcribed *PR. COH. I. L. GOR.* I could read them no otherwise than *Præfeto Cohortis primæ Legionis Gordianæ*. *Gordian III.* was so beloved of the Soldiery, that several Legions complimented him by honouring themselves with his Name, as the <sup>1</sup> *Legio tertia Italica*, which took the Addition of *Gordiana*; and the <sup>2</sup> *Legio decima gemina*, and <sup>3</sup> *Decima tertia gemina* did both give themselves the same Appellation. But which of the Legions quartered in this Island so stiled itself is not determin'd by this Inscription or any other that I know of. However, as the *Legio sexta Victrix* was all along quarter'd in the Northern parts of this Kingdom (as I observed before) where these Inscriptions were erected, I make no doubt but it was that which call'd it self *Gordiana*, tho' the numeral Distinction of VI is omitted, only perhaps for want of Room on the Stone. We find by several Inscriptions in *Camden*, that there was an *Ala* in those Parts which prided it self upon its Valour, and was therefore call'd the *Ala Augusta*; of the many Memorials it has left us of its Title, I shall only mention <sup>4</sup> one found at *Old Carlisle*, and which is the ancientest of them all, by any certainty of Date.

I. O. M.  
AL. AVG. OS  
... RTVT. APPEL. CVI  
PRAEST. TIB. CL. TIB. F. P.  
LING · · N IVSTINVS.  
PRAEF. FVSCIANO.  
II. SILANO. II. COS.

that

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<sup>1</sup> Velf. *Monum. Augusta Vindel.* p. 431.  
p. 433. 1.

<sup>4</sup> *Camd.* p. 827.

<sup>2</sup> *Grut.* p. 80.

<sup>3</sup> *Gruter.*

that is,

*Jovi Optimo Maximo, Ala Augusta ob Virtutem appellata, cui præest Tiberius Claudius Tiberii filius, provinciâ Lingonensi, Justinus præfectus, Fusciano secundò, Silano secundò Consulibus.*

This Altar was dedicated when *Fuscianus* and *Silanus* were the second time *Consuls*, that is, in the Year 188. under the Reign of *Commodus*, and Fifty Years before our *Gordian* came to the Empire. At the same place was also discover'd the Fourth Inscription by me quoted, where we find this same *Ala Augusta* styling itself also *Gordiana*; from whence I think it is not a little probable that the Legion to which this Wing appertain'd was the *Legio Gordiana* mention'd in the Inscriptions found at *Langchester*; and that Legion to have been the *Legio sexta Victrix*, from the long Continuation of this *Ala Augusta* in these Northern parts of the Nation, the constant Quarters of that Legion.

July 10.  
1718.

III. *A Letter of that curious Naturalist Mr. Henry Barham, R. S. S. to the Publisher, giving a Relation of a fiery Meteor seen by him, in Jamaica, to strike into the Earth; with Remarks on the Weather, Earthquakes, &c. of that Island.*

S I R,

**A**CCORDING to your Request I have collected what I can remember, relating to a *Meteor* I saw in *Jamaica* about the Year 1700, as I was riding one Morning from my Habitation situated about Three Miles North-West from *St. Jago de la Vega*: I saw a Ball of Fire, appearing to me of the Bigness of a Bomb, swiftly falling down with a great Blaze. As I thought it fell into the Town; but when I came within a quarter of a Mile of the Town, I saw many People gather'd together a little to the Southward in the *Savanna*, to whom I rode up, where they were admiring at the Ground's being strangely broke and plough'd in by a Ball of Fire, which, as they said, fell down there. I observed there were many Holes in the Ground, one in the middle of the Bigness of a Man's Skull, and five or six smaller Holes round about it, of the Bigness of a Man's Fist, and so deep (especially the biggest) as not to be fathom'd by what long Switches or Sticks they had at hand. I did not hear that any was so curious as to make any farther Search: It was observ'd, that the green Grass was perfectly burnt near the Holes, and a strong Smell of Sulphur remain'd thereabouts for a good while after.

Note that we had a terrible rainy Night before, with much Lightning and great Thunder-Claps, which we have

have very frequently in *Jamaica*, often killing Cattle in the Fields. Mr. *Henry Lord*, who lives at *Dry-River*, had two Sons ( big Boys ) struck dead with Lightning, in 1716, without any Wounds or Appearance of Hurt found about them. And as these Claps are much louder and stronger than any I ever heard in *Europe*, so are our Showers of Rain, pouring down in a most violent manner. We have Lightning all the Year round, but our great Rains are in the Months of *May*, *August*, and *October*. I knew *May* for two or three Years without Rain, which was lookt upon as a great Wonder; and we paid dear for it in our *Indigo*; for a Caterpillar appear'd and wove a fine Silk about the *Indigo-Plant*, and destroy'd it all, hurting nothing else. *May-Rains* us'd to destroy these Worms. *August* and *October* never go out without a Flood, we having then universal Rains, all over the Island, coming from the Sea: For we have often Rains in the Mountains from the Clouds lodging there, when we have none in the Lowlands.

Our Island is full of Mines, and, if search'd into, I question not but very rich. We are very subject to Earthquakes, several happening every Year, especially after great Rains, which fill up all our great Cracks in the Surface of the Earth: For in a very dry Time, we have them so very large, deep, and gaping so open and wide, that it is dangerous to ride over some Parts of the *Savannas*, for fear a Horse should get his Legs into them. Our Earthquakes make a Noise or Rumbling in the Earth, before we feel the Shake; and seem to run swiftly to the Westward. This is all I can inform you of this kind at present, relating to the Island of *Jamaica*, being ever ready to shew how much I am, &c.

Decemb. 19.  
1717.

*Henry Barham.*

IV. *An Attempt to prove the Antiquity of the Venereal Disease, long before the Discovery of the West-Indies; in a Letter from Mr. William Beckett, Surgeon, to Dr. James Douglass, M.D. and R. Soc. Soc. and by him communicated to the Royal Society.*

S I R,

**T**HE Undertaking I am at present engaged in, has unavoidably obliged me to consult, among others, a great Number of ancient Physical and Chyrurgical Books, written by my own Countrymen: From these I took the Hint, that the *Venereal Disease* was known among us, much earlier than the *Æra*, which has been generally assign'd for its Rise by modern Authors; for it's believed it was not known, at least in *Europe*, till about the Year 1494. Notwithstanding which, I determin, in the following Papers, to make it evident, it was frequent among us some Hundreds of Years before that Date. I could mention several Physicians and Surgeons of Eminence, who have been of the same Sentiments with me, particularly, the Learned Dr. *Charles Patin*, who has written a curious Dissertation to prove the Antiquity of this Disease, which is sufficient to excuse me from the Imputation of having started a Novelty, or being at the trouble of quoring ancient Authorities before taken notice of, from the most ancient Writers of Medicine; as the Great *Hippocrates*, *Galen*, *Avicen*, *Celsus*, &c. and even the *Holy Scriptures*. I shall in these and some following Papers, lay aside all those foreign Aids and As-

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sistances,

sistances, and trace out the Symptoms of the Disease, as they naturally arise, from the first Infection to the last destructive Period, and shew that, by searching into our own Antiquities, we may be furnished with Instances of the Frequency of the Distemper among us, in all its respective Stages, before ever our Modern Authors dream it had its Appearance in *Europe*.

I shall begin with the first Degree of this Disease, and prove from authentick Evidences, it was anciently call'd the **Brenning** or **Burning**; and that this Word has been successively continu'd for many Hundreds of Years, to signify the same Disease we now call a *Clap*; and that it was not discontinu'd till that Appellation first began to have its Rise. The most likely Method to accomplish my Design, will be first to examine those Records that relate to the *Stems*, which were by Authority allowed to be kept on the *Bank-Side* in *Southmark*, under the Jurisdiction of the Bp. of *Winchester*, and which were suppressed the 37<sup>th</sup> of *Hen. VIII.* For it's impossible but, if there were any such Distemper in being at that Time, it must be pretty common among those lewd Women who had a Licence for entertaining their Paramours, notwithstanding any Rules or Orders which might be establish'd to prevent its Increase: But if we shall find that there were Orders establish'd to prevent the Spreading of such a Disease, that Persons might be secure from any contagious Malady after their Entertainment at those Houses (which were anciently Eighteen in Number, but in the Reign of *Hen. VII.* reduced to Twelve) we may then securely depend upon it, that it was the Frequency of the Disease that put those that had the Authority, under a necessity of making such Rules and Orders. For the same Powers that granted a Liberty for keeping open such lewd Houses, must find it their Interest to secure,

as much as possible, all Persons from receiving any Injury there; lest the Frequency of such Misfortunes should deter others from frequenting them, and so the original Design of their Institution cease; from the entire sinking of the Revenues. Now I find that, as early as the Year 1162, divers Constitutions relating to the Lordship of *Winchester*, (being also confirmed by the King.) were to be kept for ever, according to the old Customs that had been time out of mind. Among which these were some, *viz.* No *Stew-holder* to take more for a Woman's Chamber in the Week than 14 *d.* Not to keep open his Doors upon Holy Days. No single Woman to be kept against her Will, that would leave her Sin. No single Woman to take Money to lie with any Man, except she lie with him all Night till the Morning. No *Stew holder* to keep any Woman that hath the perilous Infirmary of **Burning**. These and many more Orders were to be strictly observed, or the Offenders to be severely punished. Now we are assured there is no other Disease that can be communicated by carnal Conversation with Women, but that which is Venereal, by reason that only is contagious; and it's evident the **Burning** was certainly so: For, had it been nothing else but some simple Ulceration, Heat, or Inflammation, there would have been no Contagion; and that affecting only the Woman, could not be communicated by any Venereal Congress, and so not infer a Necessity of her being comprehended under the restraining Article. These Orders likewise prove the Disease was much more ancient than the Date above-mentioned; because they were only a Renewal of such as had been before established time out of mind.

But to confirm this farther, I find that in the Custody of the Bishop of *Winchester*, whose Palace was

situated on the *Bank side*, near the *Stews*, was a Book written upon Vellum, the Title of which runs thus; *Here begynne the Ordinances, Rules. and Customes, as well for the Salvation of Mannes Lif, as for to aschewe many Dyschiefs and Inconveniencents that dayley be lik there for to fall owte. to be rightfully kept, and due Execution of them to be don unto any Personne wythin the same.* One of the Articles begins thus; *De his qui custodiunt Mulieres habentes Nephandam infirmitatem.* It goes on, *Item, That no Stew-holder keep noo Woman wythin his Hous that hath any Sycknesse of BRENNING, but that he be putte out upon the payne of makeit a fyne unto the Lord of a hundred Shyllyngs.* This is taken from the Original Manuscript which was preserv'd in the Bishop's Court, suppos'd to be written about the Year 1430. From these Orders we may observe the Frequency of the Dislemper at that Time; which, with other Inconveniencies, was dayley lik there for to fall owte: and the Greatness of the Penalty, as the Value of Money then was, that is laid on it, proves it was no trifling or insignificant thing.

But the bare Proof of there having been anciently such a Disease as was called the *Burning*, may be thought to be insufficient, unless we were perfectly assured what it was, and how it was in those Times described: I shall therefore do it from an unquestionable Authority, which is that of *John Arden, Esq;* who was one of the Surgeons to our King *Richard II.* and likewise to King *Henry IV.* In a curious Manuscript of his upon Vellum, he defines it to be, a certain inward Heat and Excoriation of the *Urethra*; which Description gives us a perfect Idea of what we now call a *Clap*; for frequent Dissections of those that laboured under



under that Disease, have made it evident, that their *Urethra* is excoriated by the Virulency of the Matter they receive from the infected Woman ; and this Excoriation or Ulceration is not confined to the *Ostiola* or Mouths of the *Glandulæ Muscosæ*, as has been lately thought, but may equally alike attack any part of the *Urethra* not beyond the reach of the impelled malignant Matter. The Heat before described, which these Persons are sensible of, as well now as formerly, is a Consequent of the excoriated *Urethra* ; for the Salts contained in the Urine must necessarily prick and irritate the nervous *Fibrillæ*, and excite a Heat in those Parts of the *Urethra* which are divested of its natural Membrane ; which Heat will always be observed to be more or less, as the Salts are diluted with a greater or less Quantity of Urine ; a thing I have often observed in Persons that have laboured under this Infirmary in hot Weather, when the perspirable Matter being thrown off in greater Quantities, the Salts bear a greater Proportion to the Quantity of Urine, and thereby make its Discharge at that Time so much the more painful and troublesome.

Thus we see this very early and plain Description of this Disease among us, to be entirely conformable to the latest and most exact Anatomical Discoveries. Here is no Tone of the *Testicles* depraved, according to *Trajanus Petronius* ; no Exulceration of the *Parastatæ*, according to *Rondeletius* ; no Ulceration of the *Seminal Vessels*, according to *Platerus* ; no Seat of the Disease in the *Vesiculæ Seminales* or *Prostatæ*, according to *Bartholin* ; nor in those Parts and the *Testicles* at the same Time, according to our Countryman *Wharton* and others, who have falsely fixed the Seat of this Disease, and whose Notions, in this respect, are now justly exploded ; but a single and true Description of it, and

its Situation, about an Hundred and Fifty Years before any of those Gentlemen obliged the World with their learned Labours.

Having, I hope, sufficiently made it appear, the **Burning** was a Disease very early among us, and, given the Description of it, I shall proceed to say something of the ancient Method that was made use of to cure it. We are not to expect the Measures our Predecessors, in those early Times, made use of, should be calculated for the removing any Malignity in the Mass of Blood; or other Juices, according to the Practice in Venereal Cases at this Time; because they looked upon the Disease to be entirely local, and the Whole of the Cure to depend upon the Removal of the Symptoms: Hence 'twas they recommended such Remedies as were accommodated to the taking off the inward Heat of the Part, and cure the Excoriations or Ulcerations of the *Urethra*. The Process for the accomplishing of this, I shall set down from the before-mentioned *John Arden*, who wrote about the Year 1380. his Words are as follow, *Contra Incendium. Item contra incendium Virga Virilis interius ex calore & exco-riatione, fiat talis Syringa (i. e. injectio) lenitiva. Accipe Lac mulieris masculum nutrientis, & parum zucarium, Oleum viola & ptisana, quibus commixtis per Syringam infundatur, & si prædictis admiscueris lac Amigdalorum melior erit medicina.* There is no doubt but this Remedy, being used to our Patients at this Time, would infallibly take off the inward Heat of the Part, and cure the Excoriations or Ulcerations of the *Urethra*, by which means what issued from thence would be entirely stop't; and this was all they expected from their Medicines, forasmuch as they were entirely unacquainted with the Nature of the Distemper; and did not in the least imagine, but if the Symptoms that first attack'd the Part were removed, the Patient was entirely cured. I

I shall now, as a farther Confirmation of what I have advanced, proceed to prove, that by this **Brenning** or **Burning** is meant the Venereal Disease, by demonstrating that succeeding Historians, Physical and Chirurgical Writers, and others, have all along with us in *England* used the very same Word to signify the Venereal Malady. In an old Manuscript I have by me, written about the Year 1390. is a Receipt for **Brenning of the Wyntyl, yat men clepe ye Apegalle; Galle** being an old English Word for a running Sore. They who know the *Etymologie* of the Word *Apron*, cannot be ignorant of this. And in another Manuscript, written about 50 Years after, is a Receipt for **Burning** in that Part by a Woman. *Simon Fish*, a zealous Promoter of the Reformation in the Reign of *Hen. VIII.* in his Supplication of Beggars, presented to the King in 1530. says as follows, *These be they (speaking of the Romish Priests) that corrupt the whole Generation of Mankind in your Realm, that catch the Pockes of one Woman and bear them to another; that be Burnt with one Wom:n and bare it to another; that catch the Lepry of one Woman and bare it unto another.* But to make this Matter still more evident, I am to observe, that *Andrew Boord*, a Doctor in Physick, and Romish Priest, in the Reign of *Henry VIII.* in a Book he wrote, entitul'd *The Breviary of Health*, printed in 1546. speaks very particularly of this sort of Burning; one of his Chapters beginneth thus, **The 19th Chapter doth shew of BURNING of an Harlotte**; where his Notion of communicating the *Burning* is very particular. The same Author adds, that if a Man be **Burnt** with an *Harlot*, and do meddle with another Woman within a Day, he shall **Burn** the Woman that he shall meddle withal; and as an immediate Remedy against the **Burning**, he recommends the washing the *Pudenda* two or three

three times with White Wine, or else with Sack and Water; but if the matter have continued long, to go to an expert Chirurgion to have Help. In his 82d Chapter, he speaks of two sorts of Burning, the One by Fire, and the Other by a Woman through carnal Copulation, and refers the Person that is **Burnt** of a *Harlot* to another Chapter of his for Advice, what to do, yf he get a **Doxer** or two, so called from its Protuberancy or bunching out: For I find about that Time the Word *En'lo* was mostly made use of, to signify that sort of Swelling which usually happens in pestilential Diseases.

From hence it appears, the *Burning*, by its Consequents, was *venerial*, since every Day's Experience makes it evident, that the ill Treatment of the first Symptoms of the Disease, either by astringent Medicines, or the removing them by cooling and healing the excoriated Parts, will generally be attended with such Swellings in the Groin, which we rarely observe to happen from any other Cause whatsoever.

I shall give a few more Instances of this Disease being call'd the *Burning*, and conclude. In a Manuscript I have of the Vocation of *John Bale* to the Bishoprick of *Ossory* in *Ireland*, written by himself, he speaks of *Dr. Hugh Weston* ( who was Dean of *Windsor* in 1556. but deprived by Cardinal *Pole* for Adultery ) as follows, " At this Day is lecherous *Weston*, who is more practised in the Art of **Beech Burning** than all the *Whores* of the *Stems*. And again, speaking of the same Person, he says, " He not long ago **brent** a *Beggar* in *St. Botolph's* Parish. The same Author says of him elsewhere, " He had been sore Bitten with a *Winchester-Goose*, and was not yet healed thereof; which was a common Phrase for the Pox at that Time, because the *Stems* were under the Jurisdiction of the Bishop of

of *Winchester*. *Mich. Wood*, in his *Epistle* before *Steph. Gardiner's Oration de vera Obedientia*, printed at *Rhoan*, 1553. gives another Evidence of the **Burning**. And *William Bullein*, a Physician in the Reign of *Queen Eliz.* in a Book he publish'd, call'd *The Bulwark of Defence*, &c. printed in 1562. bringing in *Sickness* demanding of *Health* what he should do with a Disease call'd the *French Pockes*, *Health* answers, " He would not that a-  
 " ny should fishe for this Disease, or to be bold when  
 " he is bitten to thynke thereby to be helped, but ra-  
 " ther to eschewe the Cause of thys Infyrmyty, and  
 " filthy rotten **Burning** of *Harlots*.

I believe, by this time, I have sufficiently prov'd what I propos'd, that the first Degree of the Venereal Disease was very anciently known among us, under the Title of **Burning**; and that you may lose no more Time at preient upon this Subject, I shall reserve my Collections, which shew that the Disease, when it came to be confirmed, was no Novelty here in those early Times, for a further Opportunity, and detain you no longer than to express my Pleasure in professing my self, *Yours*, &c.

*London*, Feb. 4.  
 1717-18.

*Will. Beckett.*

V. *Accuratarum Observationum Astronomicarum, au-  
 no superiore & currente, cum Reg. Societate com-  
 municatarum Sylloge.*

**I**Nterest sanè Scientiæ ne pereant Observata Astrono-  
 mica, debita curâ fidisque Instrumentis ab Artifi-  
 cibus idoneis cælitus deprompta: Hoc enim solo  
 fundamento nititur Urania practica. Itaque in his *Trans-*

Qqqqqq

*actionibus,*

*actionibus*, per plusquam quinquaginta annorum curriculum, passim sparguntur hujus generis Notæ. Ausim tamen spondere vix ullas unquam reperiri posse Observationes quæ certitudine eas quas nunc damus vincant, ne dicam quæ pares sint, utpote Tubis prælongis ac Micrometris præter solitum assabre factis menluratae. Cape igitur primo.

### *Planetarum Observationes.*

Anno 1717. *Aprilis* 15°. 9<sup>h</sup> 49' T. æq. observavit D. Pound apud *Wansled*, *Jovem* jam reversum ad stellam illam, quam *Novemb.* 22°. 1716. manè corpore suo tlexerat, de qua vide N° 350. *Phil Transact.* pag. 508. *Jovis* autem centrum tum temporis distabat ab ea Stella ( quæ tertia est Geminorum in *Catalogo Britannico* ) 23' 22" boream versus; simulque ab alia vicinâ, quæ quarta est Geminorum in dicto *Catalogo*, 27' 11". atque huic fere conjunctus erat planeta.

*Aprilis* 25° sequente, eodem observatore ac loco, 10<sup>h</sup> 3' T. æq. *Jupiter* apud quatuor Fixas exiguas visus est, eas omnes præcedens, & in ipso quasi principio *Canceri*. Centrum autem planetæ distabat ab *e* 13' 00", ab *b* 13' 50", ab *f* 19' 53", & à *g* 9' 27".

Postridie vero *Apr.* 26°. 9<sup>h</sup> 7' *Jovis* centrum distabat ab *e* 8' 35", ab *f* 9' 00", à *g* 4' 5", & ab *b* 13' 50". Jamque præterierat omnes præter *f* ad quam tendebat, quamque parum admodum die crastino infra se relinquere debuit.

Eodem fere momento, horâ scil. nonâ, *Londini* visa est stella *g* in vertice *Trianguli Isoscelis* ac fere *Hopleuri* cum *Jovis* centro ac tertio *Satellite*. tum tex *Jovis* diametris ad occasum distante, nisi quod parum admodum base longiora erant crura; ac intra quadrantem horæ,

horæ, angulus ad *Jovis* centrum, qui prius major erat angulo ad Satellitem, factus est eo sensibilibiter minor.

Tres autem Stellæ *h*, *g*, *e*, sunt  $10^{\text{ma}}$ ,  $11^{\text{ma}}$ , &  $12^{\text{ma}}$  Geminorum in *Catal. Britan.* juxta quem tum temporis situm habuere, *h* in  $\odot 0^{\circ} 22' 55''$ , cum Latit. Borea  $0^{\circ} 11' 25''$ . Et *g* in  $\odot 0^{\circ} 28' 25''$ . Lat. Bor.  $0^{\circ} 3' 40''$ ; *e* vero in  $\odot 0^{\circ} 29' 20''$  cum Lat. Aust.  $0^{\circ} 8' 05''$ . Distat autem quarta *f* à Stella *g*  $11' 40''$ , ab *e*  $12' 50''$ , ac denique ab *h*  $20' 36''$ , unde constabit locus ejus. Ex his manifestum est *Jovem* Latitudinem habuisse parvam admodum Borealem, nec semiminuto majorem, saltem si dictis stellarum locis habenda fides. Hæc posteris usui esse possunt definiendo Nodorum *Jovis* motu, si quem habeant.

Ejusdem anni *Junii*  $18^{\text{to}}$   $10^{\text{h}}$  *Londini*, in ædibus Societatis Regiæ, visus est *Saturnus* Stellæ fixæ Telescopice admodum propinquus, à qua vix distabat ad Austrum una Annuli diametro, & normalis in lineam Ansarum à Stella demissa incidebat in medium Ansæ orientalis. Fixa hæc parvula nullique Catalogo adscripta tunc habuit  $\approx 12^{\circ} 58' \frac{1}{2}$  cum Lat. Bor.  $2^{\circ} 33'$  proximè; comitemque habet sibi adjunctam ac luce æqualem, quatuor minutis ad ortum distantem, ac paulò australiorem, unde facile dignosci poterit, locusque ejus si cui libeat verificari.

Eadem nocte  $10^{\text{h}}$   $30'$  *Mars* visus est prope Stellam quæ præcedit  $35. \textit{Scorpii}$ , à qua distabat Tubo 24 pedum mensurata  $7' 16''$ ; idque in recta per claram in pede Ophiuchi  $\theta$  & dictam Stellam producta. Hæc autem Stella præcedit  $35. \textit{Scorpii}$   $30' 27''$  Asc. Rect. eaque Australior est  $2' 28''$ , unde fit locus ejus tum temporis *Sagitt.*  $15^{\circ} 24' 20''$  Lat. Aust.  $3^{\circ} 59' 25''$ . Sed  $\theta$  Ophiuchi tunc habuit *Sagitt.*  $17^{\circ} 28'$ , & Lat. Aust.  $1^{\circ} 47' 38''$ . *Mars* itaque Stellam præcedebat Longitudine  $4' 58''$ ; australior ea  $5' 30''$ .

Deinde Sept. 13<sup>o</sup> 8<sup>h</sup> 5'. T. æq. *Mars* visus est à Dom. Pound præcedere claram in humero *Sagittarii*  $\sigma$  11' 54" Asc. Rect. simulque borealior erat Stellâ 22' 56". Hora 8<sup>n</sup> 25' erat distantia Planetæ à Stella 25' 00" accuratè.

Decemb. 5. 18<sup>h</sup> 30'. T. æq. consensu sæpius repetitarum observationum, invenit D. Pound *Saturnum* præcedere Telescopicam claram sibi vicinam 27' 19" Asc. Rect. Stellaque australiorem esse 1' 59". Simul *Saturnus* præcedebat  $\kappa$  in *Syrmate Virginis* 1<sup>o</sup> 25' 21", eâque australior erat 4' 05". Hinc *Saturni* locus *Libra* 29<sup>o</sup> 16' 21". Lat. Bor. 2<sup>o</sup> 22' 21". Telescopica autem tunc habuit *Libr.* 29<sup>o</sup> 40' 56". Lat. Bor. 2<sup>o</sup> 33' 43".

Anno 1718. Jan. 7. 5<sup>h</sup> 30'. T. æq. *Venus* apud duas Steilas in *Catal. Britan.* omittas observata est. Erat autem Planeta utrâque Fixâ Borealiore, distans à præcedente 32' 30", à sequente 17' 30". Stella præcedens tunc habuit *Asc.* 14<sup>o</sup> 42' 20", cum Lat. Aust. 0<sup>o</sup> 40' 10"; altera vero sequens *Pisc.* 15<sup>o</sup> 21' 55", Lat. Austral 0<sup>o</sup> 27' 15", prout ex observationibus D. *Flamstedii* colligere licet.

Jan. 15. 8<sup>h</sup> 00', T. æq. *Jupiter* præcedebat  $\eta$  in pectore *Cancr.* 3<sup>o</sup> 30' 50" Asc. Rect, fixâque Australior erat 14' 15". Hinc provenit *Jovis* locus *Canc.* 28<sup>o</sup> 20' cum Latitudine Borea 0<sup>o</sup> 36' 45".

Martii 11. 10<sup>h</sup> 36', T. æq. *Saturnus* præcedebat  $\kappa$  in *Syrmate Virginis* 18' 51", eâque Fixâ australior erat 5' 23". Hinc fit Locus *Saturni* *Scorp.* 0<sup>o</sup> 18' 34" cum Lat. Bor. 2. 44' 8". Posito scilicet, juxta *Catal. Britan.*  $\kappa$  *Virginis* occupare in 0. 24' 10", cum Lat. 2 55' 40". Eadem nocte 1<sup>h</sup> 00' *Westmonasterii* observarunt DD. *Desaguliers* & *Ray* *Saturnum* præcedere Stellam 19' 00", cum declinatione majore in Austrum 4' 45".

April 8. 11 30' Londini visus est *Saturnus* nuper *Acronychus* parum admodum occidentalior Telescopicâ clarâ, eâdemque 5 minutis borealior. Unde Fixæ locus

*Libra*



*Libra* 28.  $18^{\circ} 30''$  Lat. Bor. 2.  $41'$ . Circulus autem magnus per hanc Stellam & *Saturnum* ductus dirigi videbatur ad Stellam  $5^{te}$  magnitudinis in *Catal. Brit.* omissam, sed quæ *Hewelio* est in cuspide *Alæ Boreæ Virginis*, cuique locum assignat *Libr.* 26.  $10'$ , cum Lat.  $14. 43'$  Bor.

Eadem nocte  $13^h 20'$ , apud *Wansted*, perpendiculum à dictâ Stella Telescopicâ in lineam Anfarum *Saturni* demissum præcedebat centrum planetæ quasi sesquialtera diametro annuli; aberat autem Stella ad Austrum ab Anfarum axe  $4' 30''$ . Simul Anfæ orientalis extremitas deprehensa est in linea recta inter hanc Stellam & aliam eidem quasi longitudine conjunctam, quæ tunc à *Saturno* distabat  $24' 48''$  versus Boream. Locus autem prioris Stellæ tunc fuit *Libr.* 28.  $18^{\circ} 30''$  cum Lat. Bor. 2.  $41'$  proxime.

*Sept.* 7. circa meridiem incidit conjunctio *Jovis* & *Veneris* arctissima, cujus quidem spectaculum Astronomis nostris inviderunt Nubes. Die autem sexto præcedente mane, vel  $5^h 12^m 57^s 30''$  T. æq. apud *Wansted*, *Venus* occidentalis distabat à *Jove* 1.  $3' 28''$ . Die autem 7.  $17^h 21'$ , *Venus* jam facta orientalis à *Jove* aberat  $43' 18''$ ; ac  $17^h 34'$ , *Venus* australior erat *Jove* distantia declinationum  $14' 23''$ . Et  $17^h 39'$  capta est distantia Planetarum  $44' 4''$ . Hinc calculo accuratissimi Observatoris conjuncti sunt *Sept.* 7.  $0^h 9'$  T. æq. *Veneris* centro tum *Jovis* australiore non nisi  $1' 42''$ .

Denique *Sept.* 18. mane, apud *Wansted*, *Jupiter* visus est prope. *or Leonis*, quocum die præcedente conjunctus fuerat. *Sept.* 17.  $16^h 51'$  T. æq. *Jovis* centrum aberat à *Corde Leonis*  $24' 22''$ ; &  $17^h 6' 20''$  erat diff. Declin.  $12' 43''$ . Dein post Horam, nempe  $17^h 54'$ , facta est distantia  $24' 34''$ ; ac  $18^h 7'$  differentia Declinationum inventa est  $12' 35''$ . Hinc supputante Dom. Pound, fit *Sept.* 17.  $18^h 00'$  T. æq. *Jovis* locus  $\alpha$  26  $11' 7''$  cum Lat. Bor.  $45' 35''$ . *Observationes*

## Observationes Lunæ & Eclipsium.

Anno 1727. Jan. 12. *Westmonasterii*. observavit Dom. *Stephanus Gray* Lunæ appulsum ad quatuor Stellæ con-  
tiguas sub cornu Austrino *Tauri*, apud quas observata  
est Luna Anno 1683. Mart. 23. æ. v. ab *Hevelio* &  
*Flamstedio*. Itaque 9<sup>h</sup> 45' T. app. Luna gibba visa est  
quasi conjuncta cum Stella è quatuor præcedente, quæ  
est *Tauri* 107. *Catal. Brit.* quæque tunc Australior erat  
Lunæ limbo Aust. sesquialtero minuto. 11<sup>h</sup> 29' altera,  
quæ minor est, & ideo in Catalogo omiſſa, occultaba-  
tur paulo infra medium obscuri limbi. Ad 12<sup>h</sup> 24'  
Tertia & clarior ( 110. *Tauri* ) in ipsa fere conjunctio-  
ne sex minutis distabat à limbo boreo. Denique 12<sup>h</sup> 54'  
sequens è quatuor ( 111. *Tauri* ) limbo Boreo superior  
erat 3' 30". Locus autem præcedentis, sive 107. *Tauri*,  
ex dicto Catalogo tunc erat *Gemini* 18. 12. Lat. Aust.  
5. 18'; *Tauri* autem 110 habuit *Gem.* 19. 26'  $\frac{1}{4}$  cum Lat.  
Aust. 4. 44': Sequens vero, sive 111 *Tauri*, erat in *Gem.*  
19. 45'. Lat. Aust. 4. 48'  $\frac{1}{2}$ . Secunda parvula, ut ex  
aliis observationibus constat, Locum tunc habuit *Gem.*  
19. 17'. Lat. 5. 5' ferè.

Eodem anno Mart. 16. mane, erat Eclipsis Lunæ par-  
tialis, apud nos ob cælum nubilum inconspicua. At  
apud *Cambridg Nov-Anglorum*, Dom. *Robie* Astronomiæ  
peritissimus vidit Eclipsæos initium circa horam nonam.  
Finem vero, juxta *Paludem Meotida*. ad 11<sup>h</sup> 42' 30" sat  
accurate. Est autem *Cambridg* sub altitudine Poli 42.  
25', *Londino* 71 grad. sive 4<sup>h</sup> 44' occidentalior, ut ex  
pluribus antea observatis constat.

Dein Sept. 9. vespere, in ædibus Societatis Regiæ  
*Londini*, observarunt nonnulli è Sociis finem Eclipsæos  
Lunaris 7<sup>h</sup> 26'. Luna autem orta est juxta medium  
Eclipsæos,

Eclipseos, nec nisi paulo ante finem è nubibus horizon-tem obsidentibus sese extricaverat.

*Sept. 14.* Vesperis, hac prima vice post longum intervallum rediit Luna ad occultandum *Palilicium*. Favit autem admodum cœlum *Londini* præter solitum purum, ita ut Luna & Stella exorientes in ipso quasi Horizonte simul conspicerentur. Incidit Immersio Stellæ  $9^{\circ} 6' 20''$ , Lunâ nondum  $3^{\circ}$  altâ, in ipso quasi medio Limbi orientalis, è regione scilicet Boreæ partis maculæ illius exiguæ quam *Hewelius* Stagnum *Meridis* vocat, quamque *Ricciolus* sui ipsius nomine insignivit. Emergit autem paulo infra medium limbi obscuri ad  $9^{\text{h}} 58' 20''$ , in ictu oculi tota sua claritate effulgens; unde etiam in tam illustri Stellâ quasi nullitas diametri demonstratur.

*Septembris 23.* vesperi, incidit Eclipsis Solis vix ullibi in *Europâ* conspicua. Ex *America* autem nostrâ duplicem obtinuimus ejus observationem; alteram ex literis illustris Viri D. *Keith* Provinciæ *Pensylvaniæ* Præfecti dignissimi, qui *Philadelphię*, sub altitudine Poli  $40^{\circ} 00'$  fere, vidit Eclipsin jam cœptam ( sed quæ ante minutum temporis nondum inceperat ) ad  $1^{\text{h}} 55'$ . Circa medium Digiti erant quasi decem. Finis autem visus est accurate ad  $2^{\text{h}} 46' 35''$ .

Altera autem hujus observatio habita est ad *Cambridg Novæ Angliæ* Academiam, à Dom. *Robie*, de quo supra: Initium Eclipseos ibi observatum est  $0^{\text{h}} 23' 00''$  post meridiem. Ad  $1^{\text{h}} 47'$  defecere IX Digiti. Ad  $3^{\text{h}} 5' 10''$  desinit Eclipsis, Sole integro per Tubum 24 pedum conspecto. Hæc ex literis accurati Observatoris communicavit cum Reg. Societate Reverendus Vir D. *Guil. Derham*, R.S.S. Ecclesiæ apud *Windfor* Canonicus, &c.

*Dec. 5.* Luna paulo supra *Palilicium* invecta est: Transi-  
situm autem satis arctum observavit D. *Jac. Bradley*, A.M.  
eruditus Juvenis, qui simul ingenio & industria pollens  
his

his studiis promovendis aptissimus natus est, idemque Reverendi D<sup>ni</sup> *Pound* ex sorore nepos. Hic, cum Luna jam propemodum plena esset, Stellam contulit cum insigni illa Macula quam *Ricciolus Tychonem*, *Hewelius Sinam* appellat, & ex pluribus æqualibus distantis Micrometro ante & post captis, Stellam dictæ maculæ centro proximam apparuisse conclusit ad  $11^h 15' 8''$  T. æq. apud *Wansted*. Ad  $11^h 15' 42''$  distabat Palilicium à limbo Lunæ proximo & Austrino  $5' 55''$ . Macula autem *Tycho* ab eodem limbo aberat  $4' 16''$ . Ad  $11^h 18' 42''$  Stella erat in lineâ rectâ cum maculis *Tychonis* & *Copernici*, sive *Sine* & *Ætne*; &  $11^h 25' 27''$  T. æq. erat in rectâ cum *Tychone* & *Keplero*. Inter hæc observata est Lunæ diameter  $32' 45''$ .

Anno 1718. Jan. 29. vesperi, DD. *Desaguliers* & *Gray*, *Westmonasterii* alteram *Palilicii* Occultationem præstolabant; sed nubium interventu impediti, viderunt saltem quod  $5^h 52'$  nondum immerferat Stella; attenuatis autem postea nubibus conclusa est Emergio ad  $7^h 20'$ , è regione Promontorii *Sarmatiae Asiaticæ Hewelii*.

Feb. 19. manè. lidem observatores ibidem variè cum nubibus colluctati Eclipsin Solis ægre conspexerunt: Horâ tamen 6. 59' visi sunt deficere duo Digniti, & post unum temporis minutum chorda inter Cuspides visa est æqualis semidiametro Solis.

Apud *Wansted* autem D. *Pound* notavit ad  $6^h 54' 7''$  T. app. chordam inter Cuspides  $18' 30''$ . Ad  $7^h 17' 00''$  erat  $10' 18''$ . Ad  $7^h 19' 30''$  eadem inventa est  $8' 05''$ . Desiit autem Eclipsis ad  $7^h 23' 20''$ .

Feb. 25, vesperi,  $6^h 44'$  T. app. *Westmonasterii*, Stella prima *Hyadum* in Naribus *Tauri* ( $\gamma$  *Bayero*) visa est in rectâ per cuspides Lunæ, adeoque propemodum conjuncta; distabat autem à limbo Lunæ Austr.  $5' 51''$ . Diameter Lunæ  $31' 45''$  mensurata Micrometro.

*Feb.* 28. 8<sup>h</sup> 36' T. app. etiam *Westmonasterii*, visa est Immerfio Stellæ in Poplite *Pollucis* ( $\lambda$  Geminorum *Bayero*) sub limbi *Luna* obscuri ea parte, quæ paulo Borealior erat macula quam *Hævelius Cretam* vocat. Emerfio ipsa ob cælum minus purum non conspecta est: sed ad 9<sup>h</sup> 51' egressa erat Stella è limbo lucido, à quo distabat 3 min. circiter, è regione Boreæ partis Insulæ Majoris *Casti*.

*Aug.* 8. Luna orta est paulo infra *Palilicium*, cum quo tamen ob nubes conferri non potuit. Apud *Wansted* autem 13<sup>h</sup> 2' 00" T. app. visa est Præcedens contiguarum ad  $\sigma$  *Tauri Bayero*, (sive Penultima in nostro *Hyadum* Caralogo, in Num<sup>o</sup> 354. *Transact.* litera *q* notata) in linea recta per cuspides *Luna*, distans ab Austrino 4' 36". Ad 13<sup>h</sup> 7' 25" Stella *p* ejusdem Catalogi emerfit paulo infra medium obscuri limbi. Ad 13<sup>h</sup> 19' 4" emerfit Sequens contiguarum dictarum, tantum distans à Cornu Austrino quantum contiguæ illæ inter se, hoc est 7 min.

*Aug.* 29. Vesper, Luna fere Apogæa passâ est deliquium totalem ac fere centalem: orta autem est Eclipsi jam cœptâ. Hujus observationes maximè luculentas Regiæ Soc. exhibuit toties laudatus Rev. D. *Pound*, eo ordine quo notatæ sunt, nempe

Observ.	Tempus apparens			Eclipsi Lunæ observata apud Wansted, 29. Augusti, 1718.	
	h	'	"		
1	6	53	38	Chorda inter Cuspides Micrometro	22 37
2		55	8	Eadem repetita (mensurata	21 14
3		56	31	Repetita ——— ——— ———	19 51
4		57	49	Iterum ——— ——— ———	18 28
5		59	38	Denuo ——— ——— ———	15 00

T. appar.				Eclipsis Lunæ, Aug. 29. 1718.			
h	m	s				h	m
07	2	41		Immersio Totalis in Umbram —			
78	36	13		Stella clara in Catalogis omiſſa oc- cultata eſt à Luna, infra Paludem Mareotida Flevclii —		10	2
88	48	18		Luna cœpit emergere ex Umbra —			
9	51	13		Terminus Umbræ per med. Mareo- tidis; ſimul Chorda inter Cuſpides —		5	0
10	53	7		Chorda inter Cuſpides —		18	28
11	54	16		Eadem repetita —		9	51
11	54	59		Iterum —		21	14
138	56	18		Denuo —		22	37
19	0	48		Porphyrites emerſit ex umbra.			
15	8	3		Mons Sinai incepit emergere.			
16	9	17		Umbra per medium Sinai.			
17	10	0		Jam totus Sinai extra Umbram.			
18	11	20		Umbra per medium Ænæ.			
19	17	23		er medium Corſicæ.			
20	20	0		Per medium Lacus Nigri majoris.			
21	27	54		er medium Beſbici.			
22	28	45		Emerſit Stella prædicta.			
23	32	34		Byzantium & Horminius ſimul emergunt.			
24	33	58		Stella eandem habuit Declinationem cum Cuſpide Auſt. & clipſeos.			
25	43	28		Chorda inter Cuſpides —	18'	28"	
26	47	2		Eadem. repetita —	15	00	
279	53	0		Deſuiſſe videbatur Defectus.			

10<sup>h</sup> 30', Capta eſt Lunæ diameter 29' 45". Colla-  
tis autem inter ſe Obſervationibus, ubi Chordæ partis  
deficientis æquales deprehenſæ ſunt, provenit Eclipſeos  
medium.

Ex Obſerv.

*Medium.*

	h	'	"
Ex Observ. prima & decima tertia —	7	54	58
Ex secunda & duodecima —	7	55	3
Ex tertia & undecima —	7	55	24
Ex quarta & decima —	7	55	28
Ex quinta & nona —	7	55	25
Ex sexta & octava —	7	55	29
Quorum oranium Medium fit —	7	55	18

Non minore cum curâ eandem Eclipsin, *Londini* in vico *Fleetstreet*, instrumentis & Telescopio optimo D. *Geo. Graham* Automatopœi præstantis, observavit D. *Martinus Folkes* Armig. cum aliis quibusdam Regiæ Societatis Sodalibus, ut sequitur,

h	'	"	
6	38	0	Luna per fumum Urbis & Vapores ægre visa.
6	54	13	Chorda inter Cuspides utcumque, 21' 27"
7	2	0	Immersio Totalis in umbram.
7	42	15	Stella fixa satis clara distabat in limbo Lunæ orientali 19' 21".
8	35	18	Eadem fixa occultata est, 10' circiter minutis centro Lunæ Australior.
8	45	50	vel, ut quibusdam visum est, uno minuto tardius Luna cœpit emergere.
8	49	38	Palus <i>Marcotis</i> primo margine emerfit.
8	50	14	Integra Palus extra Umbram.
9	0	5	Montis <i>Porphyritidis</i> medium emerfit.
9	7	39	Primus margo <i>Sinæ</i> emerfit.
9	9	8	Mons <i>Sinai</i> totus extra umbram.
9	10	35	Umbra per medium <i>Ætnæ</i> .
9	12	0	Totus mons <i>Ætna</i> extra umbram.
9	18	51	Umbra per medium <i>Lacus Nigri</i> majoris.
9	27	35	Insula <i>Besbicus</i> tota emerfit.

- 9 42 21 Chorda inter Cuspides 19' 9".  
 9 51 25 Finis Eclipsæ ut quibusdam visum est.  
 9 52 45 Finis ex præcedente distantia Cuspidum  
 conclusa.  
 9 56 45 Lunæ diameter 29' 45", iterumque 29' 48".

Erat autem Umbra admodum diluta, unde orta est difficultas in dijudicandis Emerfionis & Finis momentis: Atque Maculæ etiam obscuriores clarè conspectæ sunt, pluribus minutis antequam Umbræ marginem attingerent. Stella vero quæ durante Eclipsi occultata est, locum tunc habuit  $\times$   $17^{\circ} 16' \frac{1}{2}$  cum Lat. Aust.  $1^{\circ} 6' 30''$  proximè.

Recepimus etiam Observationes hujus Eclipsæ à Rev. D<sup>no</sup> *Derham*, apud *Upminster* in agro *Essexiensi* habitas; à D<sup>no</sup> *Wright* apud *Crew* in agro *Cestriensi*; & à D<sup>no</sup> *Hawkins* apud *Wakefield* in *Eboracensi*, cum præmissis ubique fere consentientes, si adhibeantur meridianorum differentix: posito scil. quod *Upminster* sit  $1 \frac{1}{2}$  min. *Londino* orientalius, *Crew* vero 10 min. & *Wakefield* 5 min. occidentaliora.

Denique Coronidis loco observationem adjiciamus, eximiam quidem, sui generis, quod scimus, ab invento Telescopio primam; quamque indefessæ D. *Jac. Bradley* debemus diligentia. Quinto enim *Septembris* manè, Sole jam fere 30 gr. alto, vidit apud *Wansted* arcissimum Lunæ infra *Palilicium* transitum, cujus distantiam à limbo proximo, ad  $7^h 59' 00''$  T.æq. Micrometro invenit  $5' 38''$ . Ad  $8^h 17' 5''$  distabat à limbo  $1' 25''$ . Stella autem ad  $8^h 33' 15''$  erat in linea recta per Lunæ Cuspides tum obtusiusculas, nec nisi  $0' 13''$  distabat à Boreâ.  $8^h 41' 00''$  jam Cuspidem illam reliquerat  $3' 42''$ . Et  $8^h 45' 37''$  ab eadem distabat  $5' 36''$ . Lunæ diameter ad  $8^h 58'$  capta est  $31' 7''$ .



# PHILOSOPHICAL TRANSACTIONS,

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For the Months of *Octob. Nov. and Dec. 1718.*

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I. In-

**I.** *Inventio Curvæ quam Corpus descendens brevissimo tempore describeret ; urgente Vi Centripetâ ad datum punctum tendente, quæ crescat vel decrescat juxta quamvis Potentiam distantie à Centro ; dato nempe imo Curvæ puncto & altitudine in principio Casus. Per Joh. Machin, Astron. Profess. Gresh. & Reg. Soc. Secret.*

**S**it centrum Virium C, (*Fig. 1. 2*), quo centro ad distantiam CB æqualem altitudini unde Corpus casurum est, describatur Circulus BEG, & fiat angulus BCG rectus. Ponatur A punctum Curvæ infimum, ubi axi CB occurrit ad datam distantiam CA. Oportet invenire punctum Q, ubi Curva celerrimi descensus EQA occurrit circulo QF, ad datam aliam distantiam CF. Problema hoc duos habet Casus, quorum alter pendet ab Hyperbola & Circulo, alter ab Ellipsi & Circulo.

*Cas. 1.* Si fuerit Vis centripeta reciproce ut distantia à Centro. Sit KLM (*Fig. 1.*) Hyperbola quævis rectangula centro C & Asymptoto CB descripta, quæ occurrat normalibus BK, AM super ipsam BC ad puncta B, A erectis, in K & M; ordinatæ vero cuilibet intermediæ FL ad punctum F erectæ in L. Fiat CD ad CG ut  $\sqrt{AFLM}$  ad  $\sqrt{ABKM}$ , & sit DH normalis super CG: dein capiaturs Sector RCB ad Arcam HDCB ut data Area Hyperbolica ABKM ad datum Rectangulum CA  $\times$  AM. Tum recta RC occurret circulo FQ in puncto Q, quod quidem est ad Curvam celerrimi descensus EQA.

Hab-

Habebitur autem punctum E, à quo inciperet Corporis casus, capiendo Sectorem B C E ad Aream Quadrantis B C G, in eadem ratione Areæ Hyperbolicæ A B K M ad rectangulum sub C A & A M contentum.

*Coroll.* Hinc si recta R C, circa centrum C revoluta, faciat Sectores R C B proportionales Areis H D C B, in quibus quadrata Basium C D sumuntur in progressionem Arithmeticâ: rum rectæ C R interfecabunt Curvam E Q A ad distantias à centro C Q, quæ decreſcant in progressionem Geometricâ

*Caf. 2.* Si vero Vis centripeta fuerit reciproce ut alia quævis Potestas distantie à centro; sit  $n \neq 1$  Index istius Potestatis (ubi  $n$  potest esse Numerus quilibet integer vel fractus, affirmativus vel negativus) sitque  $H = C B$  altitudo maxima Curvæ quæsitæ E Q A,  $h = C A$  altitudo minima ejusdem, &  $A = C F$  altitudo alia quævis intermedia. *Fig. 2.*

In recta C G capiatur C D ad C B ut  $\sqrt[n]{h^n}$  ad  $\sqrt[n]{H^n}$ , atque etiam C H ad C D ut  $\sqrt[n]{A^n - h^n}$  ad  $\sqrt[n]{H^n - h^n}$ . Centro C, semiaxibus C D, C B, describatur Ellipsis B L D, cui occurrat ordinatim applicata H L in puncto L; & ducatur recta L K, quæ Ellipsin tangat in L, & Axi minori C D producto conveniat in K: dein Tangenti K L parallela ducatur N M, circum B E M G tangens in M & ipsi C D occurrens in N. Denique capiatur Sector R C B, qui sit ad Aream N M B L K N, inter Circulum & Ellipsin & utriusque Tangentes rectamque N K comprehensam, in ratione Numeri binarii ad Numerum  $n$ . Tum recta R C interfecabit Circulum F Q in puncto Q, quod erit ad Curvam celerrimi Decensus E Q A.

Quod si fiat Sector B C E ad aream B D G, inter Ellipses & Circuli Quadrantes interceptam, in ratione dictâ Binarii ad Numerum  $n$ , coeuntibus scilicet punctis L, D & M, G; (ob  $A^n = H^n$ ) erit punctum E unde in-

choa-

choaretur Casus Corporis brevissimo tempore descendentis ad A, descensuque suo Curvam EQA describentis, quam tangit recta CE in E, quamque ad angulos rectos secat CB in A.

Harum Constructionum Demonstrationes è Celeberrimi D. *Newtoni Quadraturis*, ejusdemque *Philos. Nat. Principiis* (Prop. XXXIX. & sequentibus aliquibus) petitæ, aliâ datâ occasione ostendentur. Problema autem est alterius generis, Describere Curvas per quas Corpora, de puncto summo E, seu principio casus, demissa, celerissimo descensu ad inferiora data puncta Q, urgente qualibet Vi centripeta, ferrentur; cujus quidem solutio in potestate est. In præsentia sufficiat generalem hujusmodi Curvarum tradidisse Ideam, earumque ad Circuli & Hyperbolæ Quadraturas relationes indicasse, absque quibus easdem Geometrice construere haud adeo proclive est.

Fig. 1,

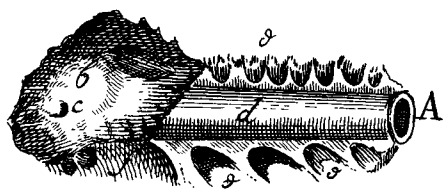


Fig. 11.

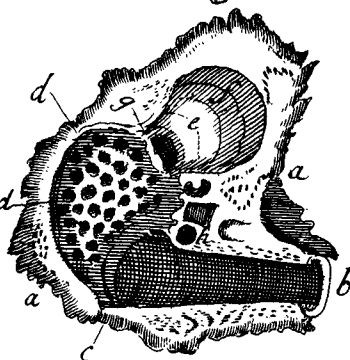


Fig. III

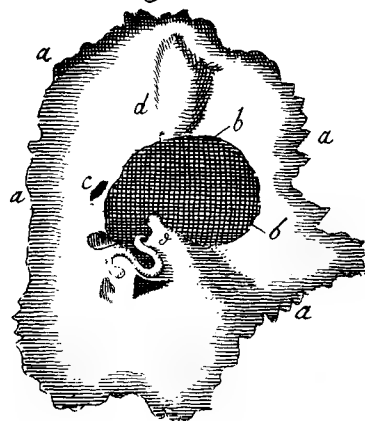


Fig. III



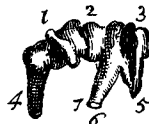
V



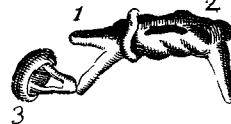
VI



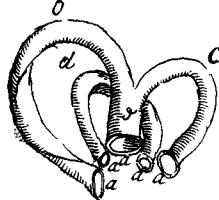
VII.



VIII.



IX.



X

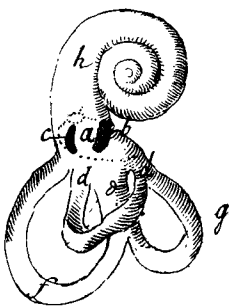


Fig. XI



Fig. 1.

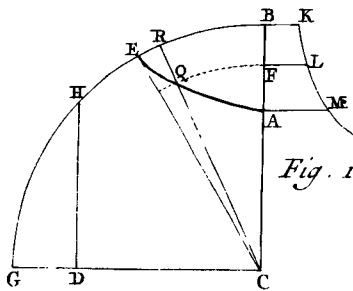
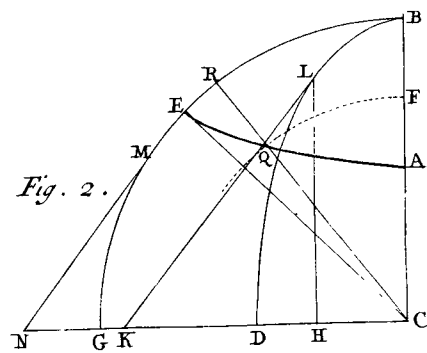


Fig. 2.





## II. *De Potentiâ Cordis.*

Differtatio Authore JAC. JURIN, M.D.

*Reg. Soc. Sodale.*

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Viro Eruditissimo

RICHARDO MEAD, M.D.

S. P. D.

*Jacobus Furin.*

**D**isquisitionem istam, Vir Clarissime, utut rudem & imperfectam, acri tamen ac perspicaci tuo Judici-  
cio multis nominibus non illibenter permitto. Quem  
enim mihi potero aut Judicem æquiores præoptare,  
aut Cognitorem deligere magis idoneum, quam cujus  
Viri candorem animi singularem, morumque humani-  
tatem, non minus atque Mentis dotes præcellentes illas,  
& optimo quoque Literarum genere perpolitas, omnes  
suspiciamus; cujusque tum acumine Ingenii, tum Judici-  
subtilitate, Theoriam Medicam videmus clarissimâ luce  
perfusam & illustratam, Usus vero medendi confirmatum  
pariter tenemus & expeditum. Nec sane quisquam est  
Mortalium, cujus calculo cogitata ista nostra comproba-  
ri magis studeamus, aut cujus auctoritate, si tibi forte  
fortuna minus displicuerint, ea contra Hominum quo-  
rundam perversorum iniquitatem tutiora sint futura. Ex  
quibus alii præjudicio ducti & famâ magnorum Nomi-

Tttttt

num,

num, quorum sententias in sequentibus passim redarguimus, nostra forsitan ne examine quidem aut perlectu digna censuri sunt. Alii vero, ut sive labore discendi, sive imperitiæ pudore se expediant, omnia scilicet, quæcunque ipsi non intelligunt, videri volunt alto supercilio contemnere. Quibus uti non gravate concedimus doctos Viros & olim exstitisse, & hodie reperiri non paucos, qui nullâ instructi disciplinâ Mathematicâ mendedi Artem tamen feliciter & cum laude exerceant; ita vicissim ipsos fateri æquum est eam doctrinam in Praxi expediendâ non inutilem, ad naturam vero & causas Morborum explorandas plane esse necessariam. Corpora enim Animalium, quod tu profecto, si quis alius, optime intelligis, cum partim solidis canalibus, partim fluido constant per eosdem jugiter propulso, Machinas esse patet, ac proinde opus esse, ad eorum Fabricam, Vires, Actiones, & agendi Impedimenta sive Morbos rite perspiciendos, rei Mechanicæ peritiâ.

De quibus tamen multa traduntur etiam à Mathematicis Scriptoribus adeo parum accurata, secumque invicem & cum ratione pugnantia, ut nobilissimæ scientiæ non modo commendationem non addant & dignitatem, sed etiam contemptui & hominum indoctorum ludibriis eandem objiciant. Quis enim, non ipse doctrinâ Mathematicâ imbutus, cum videat, Exempli gratiâ, Cordis Humani vires jam ponderi 3,000 librarum pares, jam 180,000 pondo superantes, jam vero ad uncias 5 vel 8 deductas; Aerem quoque ex Pulmone inter expirandum propulsum modo 100, modo 50,000 librarum vi; Quis inquam, qui istas conclusiones legerit discrimine tam immani à se invicem remotas, & tamen omnes demonstrationibus suis munitas, si forte se à risu temperet, non tamen inutilem plane & ineptam pronuntiaverit ad explorandas Corporis facultates scientiam Mechanicam? Sed meminerint oportet æqui rerum Judices neutiquam mirancum

mirandum esse, si quandoque in difficili Problemate vel summa Ingenia allucinentur, neque errores, siqui forte inciderint, Arti ipsi, sed Artifici imputandos. Quod ut Exemplo manifestius declaretur, libet celeberrimi Problematis de Cordis viribus indagandis solutionem novam proponere. Utque facilius mihi temeritatis opinionem detrahā, qui ejusmodi inceptum post *Alphonsum Borellum* aggredi ausim, utque viam simul Lectori expediam ad æquam certamque sententiam in tantâ scriptorum dissensione ferendam, primo loco ostensurus sum, quæ in *Borelli* demonstratione reprehendi debeant, deinde Virorum Doctissimorum, *Morlandi*, & *Keilii* solutiones, cum eâdem philosophandi libertate ad examen revocabo.

Primum nobis, & quidem longe præcipuum videtur *Borellianæ* solutionis vitium, quod Cordis Potentiam per pondus iners & quiescens exposuerit. Cor enim cum & ipsum inter contrahendum movetur, & corpora opposita, Sanguinem nempe & Arteriarum tunicas, in motum impellit, patet ejus Potentiam non aliâ ratione sciri posse quanta sit, quam ut motus hujus quantitatem cognitam teneamus. Motus autem quilibet cum pondere quiescente comparari non magis potest, quam Linea cum Rectangulo.

Secundum, quod in ipso Experimento à Circulatore instituto, neutiquam constet pondus illud suspensum fuisse à solâ Musculorum vi contractrice; quum etiam vis illa, quâ tum Musculi adhibiti, tum genæ quoque, & ipsa forsitan ligamenta divulsioni sui ipsorum & fibrarum ruptioni obstitierint, quâque Musculi etiam ex cadavere extracti pondera satis magna sustinent, venire in subsidium potuerit.

3. Quod vires Musculorum pondere æqualium a *Borelli* pares statuuntur: quod profecto dubium admodum videtur, præsertim ubi Musculi sunt figurâ dissimiles.



4. Quod integram Cordis Potentiam, quanta maxima exeri potest cum summâ fibrarum contentione & molimine, ad singulas Systoles adhiberi posuerit. Quum ipse Circulator, si pondus suspensum vel continenter, vel alternis vicibus brevissimâ quiete interpositâ, sublevare contenderet, non ita longo tempore plane succubiturus lâbori fuisset.

5. Quod Sanguinis & Arteriarum resistantiam sexagecuplam statuerit totius Potentiæ Cordis, loco ejus Potentiæ, quæ ad systolem peragendam à Corde impenditur, quæque forte totius Potentiæ minima pars est.

6. Quod in eâ ratione sexagecuplâ definiendâ errorem insignem admiserit. Nam in *Prop. 60*, loco rationis, quam obtinet Summa Potentiarum *P* & *Q*, ad Summam *R* & *S*, adhibuit rationem, quæ est inter Rectangulum ex Potentiis *P*, *Q* confectum, & Rectangulum ex *R*, *S*. Quod errati si per Propositiones sublequentes corrigatur, habebitur in *Prop. 73*, resistantia longe major quam ab ipso *Borello* definita est, nempe pondus librarum 1,076,000, loco librarum 180,000. idque secundum positiones ab ipso Viro Clarissimo usurpatas.

Denique quod pondus illud librarum 180,000 quum à Cordis Potentiâ libris 3,000 æquali superetur, miraculi cujusdam aut monstri loco Lectoribus obtrudat; & Vim Percussionis, quasi quendam Θεὸν ἀπὸ μηχανῆς in auxilium advocet. Reipsâ enim nihilo plus hic inest prodigii, quam ubi pondus 3,000 librarum pondus aliud 180,000 librarum, ad subsexagecuplam distantiam à centro Libræ inæqualium radiorum appensum, in æquilibrio sustinet.

Minora aliquot Sphalmata, & Hypotheses plures tum prorsus arbitrarias, tum alias aliis contrarias, non illibenter omittimus. Et quidem delicta supra reprehensa, aut saltem majorem eorundem partem, non tam ipsi Vi-

ro Doctissimo imputandam censemus, quam Operi Posthumo condonandam.

Proximus sequitur Vir Doctissimus *Josephus Morlandus* qui in Disquisitionibus de Cordis vi Sermonem Anglicano editis, Methodum peringeniosam exposuit Potentiam Cordis ad Experimentum revocandi. Hic autem, præter delictum supra in *Borello* reprehensum, quod Cordis vires cum pondere quiescente contulerit, nobis videtur eo quoque nomine notandus, quod integram Cordis actionem in tunicas Arteriarum distendendas impendi posuerit. Cor enim non solum Arterias tendit, sed Sanguinem quoque certâ velocitate per totum Arteriarum & Venarum tractum propellit.

Sæperest, ut Viri Acutissimi *Jacobi Keilii* solutionem, in Tentaminibus Medico-Physicis ad Oeconomiam Animalem pertinentibus, non ita pridem cum Publico communicatam, expendamus. Qui primus omnium ausus est Potentiam Cordis à *Borello* definitam, ac magno Scriptorum consensu exceptam & laudatam, non solum rejicere, sed aliam eidem infinito prope discrimine minorem numeris disertis expressim substituere.

Hunc autem censemus, præterquam quod primum illud *Borellianæ* solutionis vitium imitatus sit, in sequentibus etiam à vero aberrasse.

Quod Corollarium *Newtonianum*, quo utitur ad Cordis vires definiendas, aut male intellexerit, aut certe non satis apte usurpaverit. Pondus enim illud ab *Archimede Britannico* determinatum, quo Motus aquæ ex vase effluentis generari potest, nequaquam generat Motum aquæ; quippe quæ gravitatis vi cadendo ipsa Motum suum acquirit. Sed hoc pondus per datum tempus cadendo, Motum concipit Motui aquæ eodem dato tempore effluentis æqualem.

Præterea ponit Vir Clarissimus velocitatem Sanguinis ex Corde effluentis perpetuo æqualem per totam Systoles.

les durationem, quam nos insigniter inæqualem fieri in sequentibus ostendemus.

In Methodo illa simpliciore, quam postea adhibet Vir Doctissimus, præter delicta hæcenus reprehensa alia etiam bina admittit.

Adsumit enim Vires Cordis in diversis Animalibus eam inter se rationem obtinere, quæ est inter pondera eorundem; quod infra falsum esse demonstrabimus. Tum ponit velocitatem Sanguinis ex sectâ Iliacâ Arteriâ profluentis, eandem esse quâ ex Corde in Aortam emittitur. Atqui cum omnis fere sanguis ex Corde expulsum per Iliacam alteram resectam emittitur, patet ejus velocitatem tanto esse majorem in Iliacâ quam in Aortâ, quanto sectio Iliacæ circularis à sectione Aortæ superatur. Præterquam quod velocitas æquabilis, quâ Sanguis per Aortam fluit, longe distet ab eâ velocitate, quâcum exit ex ipso Corde.

Similiter fere redargui potest & illa Methodus, quâ usus est Vir Cl. ad rationem definiendam inter velocitates diversas Sanguinis, resistantiâ nunc oppositâ, nunc sublâtâ, per Aortam profluentis. Sed cum isto Experimento non altera solum, sed utraque velocitas major æquo reperiatur, unde ratio, quæ est inter ipsas, non magnopere perturbetur, poterit satis tuto proportio ab ipso exposita, tanquam veræ propinqua, usurpari.

Cursu hæcenus expedito, scopulisque detectis, in quos impeerunt Viri egregii supra laudati, erit modo nobis ipsi, ut in viâ difficili & erroribus plenâ, summâ adhiberi cautione progrediendum. Et primo quidem loco ad ambiguitatem præcidendam necesse est, ut id, quod quæritur, quale sit, accuratius paulo declaretur.

Cordis Virium, sive Potentiæ, nomine significamus vel ipsum Cordis Motum, dum in contractionem agitur, vel Motum ponderis cujuslibet, quod Sanguini objectum

ex

ex Corde proruenti, & velocitate idoneâ delatum in partes contrarias, Sanguinis effluxum, adeoque ipsam Cordis contractionem, æquali vi librate valet & sistere.

Potentiam istam, cum à priori vix sperandum sit ut definire possimus, quod neque fabricam Cordis interiorum, neque causâ contrahentis naturam, aut vires satis habeamus exploratas, relinquitur, ut eandem per effecta, sive à posteriori, æstimemus.

Cordis actio in Ventriculorum suorum contractione omnis consistit. Ventriculi autem inter contrahendum in sanguinem impingunt, eique Motus sui partem communicando, eundem magna vi, qua datur porta, urgent, & expellunt. Sanguis hoc modo in Arterias, Aortam & Pulmonalem protrusus, impetu in omnes partes facto, partim in tunicas Arteriarum ex Systole sua prægressâ collapsas & flaccidas, partim in Sanguinem priorem tardius fluentem impingit. Unde gradatim extrorsum truduntur Arteriarum tunicæ, & Sanguis antecedens cursu celeratur. Quod si animo concipiantur Arteriæ sectionibus transversis minimis distinctæ, primâ Sanguinis portiunculâ ex Corde in primam sectionem irruente, partim distenditur ista sectio, partim Sanguis eâdem antea contentus in sectionem proximam detruditur, eamque distendit, atque ista actio per succedentes Arteriarum sectiones continuatur. Deinde secunda, & tertia sanguinis portiuncula, & cæteræ deinceps, in primam Arteriæ sectionem incidunt, eamque paulo magis dilatant, & sanguinem eâdem contentum in proximas sectiones successive propellunt; idque fieri pergit, donec omnis sanguis ex Ventriculis fuerit ejectus. Cæterum id utique observandum est Arterias, quo magis contractæ & flaccidæ fuerint, eo minus dilatationi obistere, quanto autem magis fuerint dilatatæ, tanto fortius ulteriori distensionem Arteriarum,

riarum, quam in Sanguinis præcedentis protrusionem, sub finem vero magis propelli Sanguinem antecedentem quam distendi Arterias, quippe quæ jam rigida factæ majorem dilatationem vix admittant.

Sanguis autem ex Corde profiliens, cum, uti dictum est, Motus sui partem Arteriarum tunicis partem Sanguini præcedenti communicat, ipse necessario de pristina celeritate remittit; adeoque dum Ventriculorum contractionem moratur, novum ab iis impulsus excipit, ejusque partem, eadem ratione atque antea, tunicis Arteriarum & præcedenti Sanguini impendit, unde iterum retardatur, & alium Ventriculorum ictum suscipit, & sic deinceps, donec omnis ex Ventriculis fuerit expulsus.

Præter causam supra expositam, superest alia, quæ Sanguis ex Corde effluens gradatim retardatur, adeoque novos successive impetus excipit ex Ventriculis sese contrahentibus. Nam Sanguis in Arteriam Aortam influens, etiamsi nulli omnino resistantiæ occurrere ponatur, adeoque nullam pati Motus sui imminutionem, tamen, cum ex lato in angustum fertur, longitudine perpetim crescit, donec totus in Aortam pervenerit; cumque sectio Aortæ non minuat, necessario minuitur Sanguinis velocitas. Motus enim Sanguinis est in ratione compositâ, ex ratione Sectionis Aortæ, velocitate in eadem, & longitudine Columnæ Sanguineæ, per Theorema nostrum III. De Motu Aquarum fluentium. Cum vero ea Sanguinis portio, quæ jam pervenerit in Aortam, gradatim retardetur, retardabitur inde Sanguis ille qui adhuc Ventriculo continetur, & hinc retardabitur ipsius Ventriculi contractio. Unde Ventriculi perpetuo aliam atque aliam Motus sui partem Sanguini contiguo, his de causis perpetim retardato, communicabunt. Patet vero isthinc, ut id obiter notemus, alium esse Motum Sanguinis ex Corde erumpentis, alium ejusdem jam ex Corde expulsi, & intra Arterias fluentis.

fluentis. Item ictum, sive impulsum Ventriculorum in Sanguinem impressum, qui alioqui unicus esset futurus, & puncto temporis transigeretur, tamen causarum supra dictarum vi, quibus Sanguis perpetim retardatur, per totam Cordis Systolen continuari.

Ventriculum itaque alterutrum Cordis Sanguinem impellentem licebit spectare, ut datum corpus cum datâ celeritate impingens in aliud corpus quiescens, cui Motus sui parte communicatâ ambo corpora communi velocitate deferuntur. Æquatur autem Potentia ejusdem, vel Facto ex pondere Ventriculi & velocitate ejus initiali, priusquam in Sanguinem impingat; vel Summæ Motuum ipsius Ventriculi ac Sanguinis ex eodem profluentis, & Motûs qui tunicis Arteriarum & Sanguini præcedenti communicatus est; vel etiam, si ab illè ponatur omnis Arteriarum & Sanguinis præcedentis resistentia, Summæ Motuum ipsius Ventriculi & Sanguinis effluentis.

*Theorema I.*

*Motus, quo Machina cava inæqualiter contractilis in contractionem agitur, æqualis est Summæ Factorum ex singulis Machinæ particulis ductis in velocitates respectivas.*

Paret ex Mechanicâ.

*Corol. 1.* Machinæ Motus minor est Facto ex pondere Machinæ ducto in velocitatem earum Machinæ partium, quæ omnium celerrime moventur inter contrahendum.

2. Motus Machinæ æquatur Facto ex pondere ejusdem, ducto in velocitatem aliquam mediam inter velocitates earum Machinæ partium quæ omnium celerrime, & earum quæ omnium tardissime, moventur.

3. Si Machinæ plures similes similiter sese contrahant, velocitate mediâ, vel æquabili vel inæquabili, similiter tamen auctâ vel imminutâ in omnibus Machi-

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nis;

nis; Motus, quo Machina quæque in contractionem agitur, rationem obtinet compositam ex ratione quadruplicatâ Diametri homologæ ipsius Machinæ, & ratione inversâ temporis, quo Machinæ contractio perficitur; vel rationem compositam ex ratione ponderis Machinæ, ratione ejusdem ponderis subtriplicatâ, & ratione temporis inversâ. *Theoremata reliqua huc spectantia in Transactione proxime edenda exhibebuntur.*

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III. *A Brief Account of the Contagious Disease which raged among the Milch Cows near London, in the Year 1714. And of the Methods that were taken for suppressing it. Communicated to the Royal Society by Thomas Bates Esq; Surgeon to His Majesties Houshold, and R. S. S.*

**A**Bout the middle of July the Distemper appeared at *Islington*, and thereupon their Excellencies the Lords Justices having notice of it, were pleased to Command that I should examine into the truth of the Report of its being Contagious; and order'd the Lord *Harcourt*, then Lord *High Chancellor*, to grant such Authority as wou'd be proper to make the Discovery. Accordingly Mr. *Milner*, Mr. *Offley*, Mr. *Richardson*, and Mr. *Ward*, four Justices of the Peace for the Countrey of *Middlesex*, were appointed to make the necessary Examinations.

Pursuant to those Orders we went to *Islington*, where Mr. *Ratcliff* had lost 120 out of 200; Mr. *Rufford* 62 out of 72; and Mr. *Pullen* 38 out of 87. They were very unwilling to own it, because so soon as it should be known, none wou'd buy their Milk; but Mr. *Ratcliff*, a Man of good Judgment in Cattle, after much perswasion, gave us the following account, *viz.* That they

first

first refused their Food; the next Day had Huskish Coughs, and voided Excrements like Clay; their Heads swelled, and sometimes their Bodies. In a Day or two more there was a great discharge of a Mucous Matter by the Nose, and their Breaths smelled offensively. Lastly, a severe Purging (sometimes Bloody) which terminated in Death. That some died in three Days, and others in five or six, but the Bulls lived eight or ten. That during their whole illness, they refused all manner of Food, and were very hot.

We then advised with several of the *Cow-leeches*, or Doctors, who all agreed that it was a Murrain, or rather a Plague; and that the Methods they had tried for a Cure, had proved unsuccessful. This Disease was so surprising, that some of those Men who used to look after them, were afraid to go near them.

We then ordered some of the sick Cows to be Housed, and several sorts of Cattle to be kept with them, to see whether the Contagion would affect any other Species.

The next Day I made a Verbal Report to their Excellencies, of all the several Opinions and Discourses which I have had about it, and left them debating what Method to take; at last I was called in, and Ordered to consider of it again the next Day, and to deliver to them in Writing what would be proper to be done. Accordingly I drew up, and gave them the following Proposals.

I. That all such Cows as are now in the possession of Mr. *Ratcliff*, *Rufford*, and *Pullen*, be Bought, Kill'd, and Burnt: or, at least, that the Sick be Burnt; and the Well kept and secured on the Grounds where they now are, that such of them as Sicken or Dye of this Distemper may be Burnt.

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II. That



II. That the Houses in which those Sick Cows have stood be Washed very clean, and then smoaked by the burning of Pitch, Tarr and Wormwood, and be kept three Months at least before any other Cows are put therein.

III. That the Fields where those Sick Cows have Grazed, be kept Two Months before any other Cows are suffered to stand or Graze thereon.

IV. That the Persons looking after such as are III, shou'd have no Communication with those that are well.

V. That the same Methods be Observed if any other of the Cow-keepers shou'd get this Distemper among them; and that they be all Summoned and told, that as soon as they perceive any of their Cows to refuse their Meat, or have any other Symptoms of this Distemper, that they immediately separate them from their others, and give notice to such Persons as your Excellencies shall appoint, that they may be Burnt; and the places where they have stood or Grazed to be ordered as before.

VI. That the Cow-keepers be required to divide their Cows into small Parcels, not more than ten or twelve in a Field together; and that they be allowed such satisfaction for complying with these Proposals, as your Excellencies shall think fit; all which is most humbly submitted, &c.

The next day their Excellencies consulted the four Gentlemen before-named, and gave them Orders to comply with the preceeding Proposals, and to allow *Forty Shillings* for every Sick Cow which they Burnt, that belonged to Mr. *Ratcliff*, *Rufford*, and *Pullen*; but the free intercourse which both Masters and Servants had had with each others Cows (before we were appointed)

had spread the Contagion; and the Disease began soon to appear in several other Neighbouring places.

The Gentlemen then summoned all the Cow-keepers in the County, and acquainted them with the above-named Proposals (to most of which they readily Complied, as being visibly their interest) and offered them *Forty Shillings* for every Cow which they Burnt, that had not been Sick above twenty-four Hours; but for such as had been longer ill, or were Dead, they would allow them only the value of their Skins and Horns.

Some of the Cow-keepers appeared not content with this Regulation, and believing that the Disease would become general, design'd to have sold their Cows at some distant Market; which the Gentlemen having notice off, appointed several Butchers to Watch near their Grounds, and count their Numbers every Morning, with Orders to follow such as they sent to any Market, and prevent their being sold, by telling the people what they were.

Another great Obstacle at the first was the Cow-keepers not owning the Disease, till they had lost several of their Cows; for so soon as it was known that any Man had but one Sick, none would buy his Milk; and to those who kept many Cows, that loss was considerable.

Nor was there ever wanting one or other who gave them hopes of a Cure.

To obviate these three difficulties, the Gentlemen encouraged them to hope for a Brief, but assured them that such only as complied with these Directions, should have any benefit by it. Accordingly they ordered a daily account to be taken of the Conduct of each Cow-keeper, and allowed or disallowed their pretensions to this Brief, as well as to the *Forty Shillings per Cow*, as they complied or disregarded these Directions.

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This had a pretty good effect; but here in *England*, where every Man is at liberty to dispose of his Cattle as he pleases, nothing but making them sensible that it was each Mans particular interest to comply with these Methods cou'd do; this, tho' true in fact, yet the Reader will readily judge to be very difficult among such a Number; but the Gentlemen spared no labour to accomplish it; for that purpose they summoned them once or twice every Week, urged all that cou'd be said to induce their Compliance, and omitted no warrantable means to frustrate their Folly.

I had Orders from the beginning to assist those Gentlemen with my Advice, which I did at most of their Meetings; as also to make a stricter enquiry into the Disease by Dissections, &c.

Accordingly I discoursed the *Cow-leeches* about the Customs and Diseases that Cows were subject to, and consulted such Books as treated of them; but concerning this Disease, I cou'd gain but small assistance from either.

I then made Dissections of sixteen Cows, in different degrees of Infection; and found the Putrefaction of their *Viscera* to encrease, in proportion to the time of their Illness.

The first five that I opened, had hearded with those that were Ill, and the Symptoms of this Distemper were just become visible; in these, the Gall-bladders were larger than usual, and filled with Bile of a natural Taste and Smell, but of a greener Colour. Their *Pancreas's* were shrivelled, some of the Glands obstructed and tumified. Many of the Glands in their *Mesenterys* were twice or thrice their natural bigness. Their Lungs were a little inflamed, and their Flesh felt hot. All other parts of their *Viscera* appeared as in a healthful State.

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The next six that I opened, had been ill about two Days ; in them the Livers were blacker than usual, and in two of them, there was several Cysts filled with a Petrified Substance like Chalk, about the bigness of a Pea. Their Gall-bladders were twice their usual bigness, and filled with Bile of a natural Taste and Smell, but of a greener Colour than the first. Their *Pancreas's* were shrivelled, some of their Glands very large and hard, and of a blackish Colour. The Glands in their *Mesenterys* were many of them five times their natural Bigness, and of a blackish Colour. Their Lungs were inflamed, with several small Cysts forming. Their Intestines were full of red and black Spots. Their Flesh was very hot, tho' not altered in Colour.

The five last that I opened, were very near dying ; in them I found the Liver to be Blackish, much Shrivelled and Contracted, and in three of them, there was several Cysts as big as Nuts or Nutmegs, filled with a Petrified Substance like Chalk. Their Gall-bladders were about three times their usual bigness, and filled with Bile of a natural Taste and Smell, but of a deep Green Colour. Their *Pancreas's* were Shrivelled and Contracted, many of their Glands very large and hard, and of a black Colour. The Glands in their *Mesenterys* were many of them distended to eight or ten times their natural bigness, were very Black, and in the *Pelvis* of most of those Glands in two Cows, there was a yellow Petrefaction, of the consistence of a sandy Stone. Their Intestines were the Colour of a Snake, their inner Coat excoriated by Purging. Their Lungs were much Inflamed, with several Cysts containing a yellow Purulent Matter, many of them as big as a Nutmeg. Their Flesh was extream hot, tho' very little altered in Colour.

I have

I have here only given you a general account of my Dissections, in the three different Stages of the Disease; for as the difference was but small, and the Disease incurable, it could neither be useful nor pleasant to the Reader, to have each particular Dissection at large, tho' I have now the Minutes by me. But the following Cases being very extraordinary, I cou'd not omit the mention of them, *viz.* In one of them the Bile was Petrified in its Vessels, and resembled a Tree of Corral, but of a dark yellow Colour, and brittle Substance.

In another there were several Inflammations on the Liver, some as large as a half Crown, cracked round the Edges, and appeared separating from the sound part, like a Pestilential Carbuncle.

In a Third, the Liquor contained in the *Pericardium* (for Lubricating the Heart in its Motion) appeared like the subsidings of *Aqua Calcis*; and had excoriated, and given as yellow a Colour to the whole Surface of the Heart and *Pericardium*, as *Aqua Calcis* cou'd possibly have done.

In giving my Opinion of this Distemper, I must beg leave to premise, that all Cows have naturally a Purgation by the *Anus* for five or six Weeks in the Spring, from (as the Cow-keepers term it) the firmness of the Grass; during which time they are brisk and lively, their Milk becomes thinner, and of a blewish Colour, sweeter to the Taste; and in greater Plenty: but the Spring preceeding this Distemper, was all over *Europe* so dry, that the like has not been known in the Memory of any one living; the consequence of which was little Grass, and that so dry and void of that firmness which it has in other Years, that I could not hear of one Cow keeper, who had observed his Cows to have that Purgation in the same degree as usual; and very few who had observed any at all. They all agreed that

that their Cows had not given above half so much Milk that Summer as they did in others; that some of them were almost dry; that the Milk they did give was much thicker, and yellower than in other Years. It was observed by the whole Town, that very little of the Milk then sold wou'd Boyl without turning; and it is a known Truth, that the weakest of the common Purges you can give a Cow entirely takes away her Milk; from all which Circumstances, I think it evident, that the want of that natural Purgation was the sole cause of this Disease; by producing those Obstructions, which terminated in a Putrification and made this Distemper Contagious.

During my daily Conversation at that time with Cow-keepers, &c. there occurred many other Circumstances of less Moment, to confirm me in this Opinion: but as there was no one reason to give me the least notion of any other Cause, I shall not trouble the Reader with a useless detail of them.

Cows are likewise subject to a Purgation (tho' in a less degree) from the same quality in the Grass, about the latter end of *September*; which is called the latter Spring; and which I believe contributed not a little, to the preventing the encrease of this Distemper; for this Purgation coming so soon after the Disease appeared, it is not unreasonable to suppose, that it freed such Cows as were not much injured, from the ill effects of those Obstructions, occasioned by the want of their Vernal Evacuations.

Several Physicians attempted the Cure, and made many Essays for that purpose; but the Dissections convinced me of the improbability of their succeeding, with which I acquainted their Excellencies. However they having received the following *Recipe* and Directions from some in *Holland*, said to have been used

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there with good success, gave me Orders to make tryal of it: But the effect was answerable to my expectation, for in very many instances, I was not sensible of the least Benefit.

*Herb. Aristoloch. Rotunda,*  
*Veronica, āā M.viij*

*Pulmonaria,*

*Hyssopi,*

*Scordij, āā M. 4*

*Rad. Gentiana,*

*Angelica,*

*Petasitidis,*

*Tormentilla,*

*Carlina, āā lb ss.*

*Bacc. Lauri,*

*Juriperi, āā ℥xij Misce fiat Pulv.*

See *Phil. Transact. N<sup>o</sup>. 338. in fine.*

This Powder is to be given in Water, one Ounce at a time, three or four Mornings successively; then rest four Days, and if the Disease continues, repeat the Powders in warm Water, as before.

I think there is no one Method in Practice, but what was tryed on this Occasion, tho' I cannot say that any of them was attended with an appearance of Success; except that of Bleeding plentifully, and giving great quantities of Cooling and Diluting Liquids. But by this Method, the instances of Success were so few, that they do not deserve any further mention.

Their Excellencies being informed that the feeding Cows with Distillers Grains was a new Custom, and was the cause of this Disease, gave me Orders to examine into the Truth of it; but upon enquiry, I found it to have been the Practice of several of the Cow keepers above twenty Years, without the least appearance of

any inconvenience; and that some of those Persons who had suffered most, had never given any. Nor is there any difference between those of Brewers and Distillers, only that the latter are the dryer.

It was likewise said, that the want of Water was the cause of this Disease, for that the Springs and places where People used to Water their Cows, were almost every where dry; and that many were obliged to send them several Miles for Water. This might produce some Diseases, but such only as they got by the fatigue of being driven so far; for Mr. *Ratcliff*, Mr. *Rufford* and Mr. *Pullen*, the three Persons where this Disease first appeared, had the New River Water running thro' the very Grounds where their Cows constantly Grazed, and cou'd drink at their Pleasure, and so had most of the Cow-keepers at *Islington*.

There were at that time several other reports of the cause of this Disease, but none that had a shew of Reason.

About the latter end of *September*, the Disease increased, and the Numbers brought to be burnt were so great, that it cou'd not be well executed; therefore it was judged proper only to bury them fifteen or twenty Foot deep: but first to make large Incisions in their most Flethy parts, and to cover them with quicklime.

At the same time, having notice that it was a Custom with the Cow-keepers, to send their Calves when a Week old to *Rumford*, &c to be Sold; and apprehending by this means that the Contagion might be carried into the Country, I required all such as had Sick Cows, to bring their Calves to be buried; to which they readily consented, and were allowed from *Five to Ten Shillings per Calf*.

In the beginning of *October*, being informed that some of the Cows in *Norfolk*, *Suffolk*, and *Hertfordshire*, had



got this Disease, and apprehending that it wou'd become general; I gave in the following Report to a Committee of Council.

The Distemper among the Cattle encreasing, and beginning to appear in several other Counties, I thought it my Duty to acquaint your Lordships, with the hazard that may attend their not being duely buried. It is the Opinion of all Authors in Physick that treat of Contagious Diseases, as well as of several of the Physicians in Town, that a Putrifaction of so many Cows as there is reason to fear will dye of this Distemper, may produce some Contagious Disease among Men; unless they are buried so deep that the Infectious *Effluvia* cannot injure the Air, which I am certain has very seldom been complied with, except in the Counties of *Middlesex*, *Essex*, and *Surry*, the Gentlemen employed being capable of acting in those Counties only. It is affirmed by several now living, that there was a Mortality among the Cattle, a little before the last great Plague in the Year 1665, which was imputed to the want of a due Care in burying them. And your Lordships may know of what importance it was judged by the King of *Prussia*, the States of *Holland*, and several other Princes and States, by the Care they took to publish Decrees and Placarts, commanding them to be buried upon pain of Death, or other severe penalties; and I humbly conceive it wou'd be necessary, not only to bury those which shall Dye, but that such as are already Dead may have the same Care; as also that they be buried nine or ten Foot deep at least. All which is most humbly submitted, &c.

Their Lordships thought fit to defer all proceeding upon this Report, till the Distemper becoming more general shou'd make it Necessary; but I thank God that Necessity never happened, for within three Weeks

or

or a Month after the giving in of that Report, the following particulars concurred to put an end to the Disease.

The Cows began their latter Purging, which contributed much to prevent the Disease from appearing in fresh Places; and the Cow-keepers were convinced that the Disease was incurable.

The knowledge of the Disease was spread all over *England*, so that none wou'd buy a Cow in the Country; and the Gentlemen prevented their being kill'd in Town, by having the Markets examined daily; and such Meat condemned as appeared Suspicious.

They now divided their Cows into small Parcels, by which they lost only that in which the Disease happened; whereas before that Method, when one Cow got this Disease, if she had herded with One, Two, or Three Hundred (the Contagion was such) scarce one did escape.

Those who had no Sick Cows avoided all Communication with such as had.

They likewise found that the keeping their Cows so long when Ill, had been the chief Cause of their Loss; they therefore now brought them to be Buried on the first appearance of the Disease, before the Contagion cou'd possibly have got to any great height.

These were the effects of the Cow-keepers dear bought Experience; but it was the indefatigable Care and Diligence of those four Gentlemen, who gave a daily Attendance, both early and late, that secured *Great Britain* from that terrible Ravage, which was made by this Distemper in several parts of *Europe*.

The severity of this Disease in *England* did not last above three Months; tho it was not entirely suppressed till about *Christmas*: But in several other Countries it continued two or three Years; and I am credibly assured,

ured, that in *Holland* it now rages with as much violence as ever; and that they have lost in Cows, Oxen and Bulls, above Three Hundred Thousand.

The Providence of God has so disposed the matter of Animal Bodies, as to render Contagious Diseases very seldom infectious to different Species; but Experience demonstrates, that Contagions may be communicated to the same Species, by touching the Woolen, Linnen, &c. to which the Infectious *Effluvia* of the Diseased had adhered, tho' the two Bodies should be at a very great distance; and I verily believe that more Hundreds died from the Infection, which was carried by the Intercourse that the Cow keepers had with each other, than single ones by the original Putrification.

The Nature of Contagious Diseases are but little understood, and it would neither be agreeable to my Design, nor useful to the Publick, to say more of this than what was evident: But I have been particularly careful, not to omit any thing Material, either for describing the Disease, or manifesting the Methods that were taken for suppressing it; because it is more than probable that the same Care wou'd be equally successful in any other Species of Cattle.

The number of Bulls and Cows lost by this Disease, in the Counties of *Middlesex*, *Essex* and *Surry*, were Five Thousand Four Hundred and Eighteen; and of Calves, Four Hundred and Thirty Nine; and the Money issued for them, at *Forty* or *Ten Shillings per Cow*, &c. was the Royal Bounty of his Majesty, from his own Civil List: and tho' neither the four Gentlemen, nor I, made any demand for a Reward, or for Expences, yet it amounted to 6774 *l.* 1 *s.* 1 *d.* But the entire loss to the Cow-keepers, as delivered in upon Oath, was 24500 *l.* (exclusive of the 6774 *l.* 1 *s.* 1 *d.*) tho' computed but at *Six Pounds per Cow*; which at a Medium, was

was not more than their Prime Cost; the dearness of keeping them near *London* necessitating the Cow keepers to buy the very best.

His Majesty was further pleased, on the Solicitation of the four Gentlemen, to grant a Brief for the 24500 *l.* but the many false Reports that were then industriously propagated, to lessen the value of those poor Mens losses, so frustrated that Charity, that the entire Sum Collected (the charges of Collecting being first paid) was but 6278 *l.* 2 *s.* 6 *d.* which on a Dividend, amounted to *Five Shillings and Three Half Pence* in the Pound, computing their Loss as above, at *Six Pounds per Cow*; tho' if we consider their Contracts with Brewers for Grains, their Rent of Grounds which lay useless, Servants wages, &c. their real Loss may (by a modest Computation) be allowed to be *Ten Pounds* for every Cow that died.

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#### IV. *A Description of the Organ of Hearing in the Elephant, with the Figures and Situation of the Officles, Labyrinth and Cochlea in the Ear of that large Animal. Communicated to the Royal Society, by Dr. Patrick Blair, R. S. S.*

**I**N the Description I formerly wrote to the Honour'd Sir *Hans Sloane*, Barr. of the *Elephant* I Dissected in *Lundee*, *Ann*o 1706. which he was pleased to Communicate to the *Royal Society*, as you have it in *Philos. Trans.* N<sup>o</sup>. 226 227. I treated of the Bony part of the Ear of that prodigious Animal a little too superficially: because I was unwilling at that time to break up the *Os Petrosum* of the right Ear, which had accidentally  
been

been separated on dividing of the Skull, by which the account I then gave of the *Linea Semilunares*, or *Labyrinth* and *Cochlea* was but *Lame*. But I have chosen since rather to destroy that Bone (however seldom such Bones are to be met with) than that the Publick should be depriv'd of an exact Description of that curious *Organe*, and that I may give a clear Idea of all its Bony parts, I shall repeat what I formerly advanc'd upon that Subject, and add what Improvements I have made upon it since.

Before I proceed, 'tis fit I observe that the *Auris Externus* of this big Creature lyes flat, and not Protuberant as in other Quadrupeds, whose Cartilaginous Substance is capable of divers Motions perform'd by several Muscles, whereby the inner Ear is preserv'd from the great violence of the External Air, which upon some occasions might perhaps injure or break the thin and delicate Membrane of the *Tympanum*. It is also for this reason that the *Meatus* is further guarded, by the Contorsions and oblique Position of the Cartilage at the Orifice of the *Meatus*, which only admits of a determinate quantity of Air, sufficient for the vibration of the *Membrana Tympani*, by which a distinct sound is convey'd to the *Sensorium commune*; whereas did the Air admitted exceed its due proportion, nothing but the confus'd Idea of a Sound would follow, such as resemble the rushing of Waters, &c. or that noise often observ'd when, by a supervenient Cold or the like, obstructions are generated within the Ear it self. And in Man, because the *Auris externus* is also flat, not only are these turnings and windings observable in the Cartilage at the entry, but the *Meatus* it self is likewise obliquely Situated, to prevent the aforesaid inconveniencies. But there is no need for such a contrivance in the *Elephant*, whose external Orifice of  
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the *Meatus* is patulent, open (scarfe being guarded by the Cartilage) and streight, whose length (it reaching from the external to the internal Table of the Scull) is sufficient to prevent the accession of too great a quantity of Air to the *Tympanum*; for in its progress most of the *Columna Aeris* beat against one or other of the sides of the *Meatus*, in so much that their force is inhibited, and only so many as suffice to convey the Sound, can reach the *Tympanum* it self.

The *Meatus Auditorius* then is a long streight Tube or *Canule* situated Horizontal-ly, and reaching from the outer to the inner Table of the Scull, in Figure not unlike the Barrel of a Pistol, but somewhat Oval, the sides of whose Cavity are hard and solid, about the thickness of a Half-penny, from whose outer Part several of the *Lamina* betwixt the two Tables of the Scull do arise, (Fig. I.) Its Cavity is an Inch or  $\frac{3}{4}$  of an Inch Diameter, and length  $9\frac{1}{2}$  Inches; being somewhat enlarg'd as it arrives at the *Crena* for the *Membrana Tympani*. (Fig. II.)

*Meatus Auditorius.*

This *Crena* is two Inches in Circumference, within which is the *Cavitas Tympani*, consisting of two different Surfaces; the one much deeper and Cellulous, the other more superficial and Smooth. The first runs perpendicularly down  $\frac{1}{2}$  Inch from the *Crena Tympani*. Its bottom is variously divided into several *Celluls*, not unlike a Honey Comb, but irregularly dispos'd. Its Bony *Lamina*, by which these *Celluls* are distinguish'd from each other, are thicker at the Top than at the Bottom, they being one Line, two Lines, or  $1\frac{1}{2}$  Line distant from each other, and about  $\frac{1}{4}$  Inch deep. Could I have got it so well cleans'd as I wish'd for, doubtless I might have observ'd their Communication with each other, by means of certain Orifices which serve to convey what super-

*Crena and Cavitas Tympani.*

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fluus

fiuous Moisture is contain'd in them for we may reasonably suppose, as in all other Cavities of the Body, there are certain Glands for separating proper Liquors convenient for the uses design'd; so here there seems to be a necessity for separating a certain quantity of Moisture, fit to lubricate the Muscles of the Ossicles, and facilitate their Motion; as also to preserve the *Membrana Tympani* from becoming too dry. This dryness of the *Membrana Tympani*, and the thickness of the Liquor separated by these Glands, is often the cause of a Deafness in Human Subjects; especially those that are advanc'd in Age. This cellulous Structure of the *Cavitas Tympani*, seems to be very proper for receiving of the superfluous Humidity; and these Communications are requisite for conveying it from one Cellule to another, till it is emptied into the *Receptaculum Commune* the *Aqueduct*, whereof hereafter.

This first or cellulous Cavity is two Inches broad, and reaches from the *Crena Tympani* to the *foramen Ovale*, or entry into the *Vestibulum*, which is shut by the *Stapes*. The second Part of this Cavity is more superficial (*Fig. II. (e)*), in form not unlike a Pear, from a narrow beginning becoming broader and more superficial, terminating Semicircularly, smooth in the Bottom, and having several incurvated Lines running across it; it reaches much farther than the *Vestibulum*, being one Inch five Lines from before to behind, and one Inch transversely where broadest. What superfluous Moisture it contains is discharg'd into the fore-named *Aqueduct*.

Beside the above-mentioned uses for these two Cavities, *viz.* to receive and discharge the superfluous Moisture; they are also most beneficial and assisting to the Hearing: for, no sooner is the external Air modulated, and the *Membrana Tympani* mov'd thereby,  
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than the Sound is conveyed by the *Cofficles* to the *Nervus Auditorius*, and the Undulation continued, first by the *Anfractuosities* of the first Cavity, and then by the *Gyres* and incurvated Lines of the second, so that we may easily account for the acute Sensation of Hearing, wherewith *Elephants* are said to be endow'd: For as the Tame ones are most exact in obeying their Masters commands; so the wild Ones are soon aware of what Traps or Snares are laid to catch them, by the tremulous Motion convey'd to their Ear from the Cavernous parts of the Earth, where the Pit into which it is expected they should fall, is digg'd. It is easy therefore to explain whence the acuteness of the Sensation of this Animal may proceed; for as the *Nervus Olfactorius* has a large Space and Pounds wherein to be dispers'd, viz. the two Cavities of the *Proboscis*, which are both long and large, so that scarce any *Columna aeris* can enter them, but some one or another of the Filaments of the *Nervus Olfactorius* dispers'd in these Cavities must be toucht, whereby the Idea of smelling must be conveyed to the *Sensorium commune* in a more intense Degree, and the Animal soon become sensible of whatever approaches that is noxious or nauseous to it. and thereby is taught how to avoid it; so this Structure, for a quick conveyance and long continuance of the Sound, is a great means both to make the *Elephant* soon receive the Sound and have a deep impression of it.

The *Aqueduc* is a flat Tube or Pipe, whose Orifice is so situated betwixt the two fore-mentioned Cavities, that if there be any superfluous Humidity contain'd in them, it must needs be discharg'd (at least in this Animal) into the Mouth; for as it is situated where the first Cavity terminates, so the second, from a broader and more superficial be-  
*The Aqueduc.*



ginning must needs discharge its Moisture, by its more narrow and deeper termination, into this receptacle; also it descends directly towards the Mouth, passing through the Scull below the hole for the Jugular Vein (*mm*) betwixt the hole for the Carotid Artery, (*pp*) and that for the *Arteria dura matris* (*qq*) whence descending (*nn*) it is joyn'd with its

*Osteographia Elephantina, or Philos. Transact. No. 327. Tab. 3. Fig. 3.*

Fleshy part, which discharges it self into the Mouth on each side, behind the back part of the inner Teeth of the upper Jaw. This situation of the Aqueduct makes it plainly appear, that its Use is to receive the superfluous Moisture from the *Cavitas Tympani*; for beside the Glands above-mentioned, fit for separating such a quantity of Humidity as may lubricate the Muscles and facilitate both their Motion and that of the *Officles*; the very Vapours that arise in such a Cavity as that of the *Tympanum* in this Animal, must at last be converted into a Liquor, and that must either again be receiv'd into the Blood Vessels, or otherwise discharg'd by such a Receptacle as this. Further if there be a necessity for Glands in the *Meatus Auditorius* without the *Tympanum*, to separate a certain Liquor, by which the acrimonious Particles of the Air are obtunded, and hindred from being offensive to the Nervous Membrane of the *Tympanum*, (which must be of a most acute Sensation) and for moistning it, by which it the more easily receives the Vibration of the Air; so such Glands as these seem to be most requisite in the *Cavitas Tympani* for the Uses above nam'd. And since what superabounds of this Moisture, cannot be discharg'd outwardly as that of the *Meatus*, this Aqueduct seems to be most convenient for that purpose. Some are of opinion that this Aqueduct is also assisting to the Hearing, especially in Men; because it is generally observ'd that

that they who are Deaf, open their Mouths wide, when they are desirous to hear more distinctly: But I see not how that can be, for tho' the Cavity of the Bony part of the Aqueduct, in most of Animals, is proportionally large enough; yet its carnous or fleshy Part lyes for the most part so flat, and its two sides are so collaps'd together, that scarce any Air can be admitted, at least so far as to be subservient to the Hearing.

The *Officles* in this as in other Animals are three or rather four in number; for though I did not procure the *Os quadrangulare* of *Du Verney*, yet I have good reason to believe it was there; because there is a conspicuous *Sinus* in the extremity both of the *Incus* and *Stapes*, where they are articulated, so big as to contain the Head of an ordinary Pin; and when I consider the Angle which must have been form'd by the articulation of these two Bones, I look upon this small Bone to serve for the same purposes as the *Patella* in the Knee, and *Sesamoide* Bones in the Fingers and Toes.

*The four Bones  
of the Ear.*

The *Malleolus* is an irregular Bone, and doubtless has been endow'd with pretty large Muscles, because of the rugosities, protuberances and *Sinus*'s observable in it. It has a protuberant Head (*Fig. IV. (1)*) four Lines broad, next to that a *Crena* or semicircular *Sinus*, (*2*) after which the Bone is rais'd, affording a protuberant Margin to an oblong *Sinus* (*3*) for receiving the head of the *Incus*, four Lines broad. The opposite part of this *Sinus*, or back part of the Bone, is convex of an unequal rugous surface, with a great many protuberances and depressions, for the Origins and insertions of the Muscles, for the space of five Lines; where it forms an Angle, from whence it becomes Flat and Smooth, being three Lines broad and reaching four

*The Mal-  
leolus.*

Lines

Lines to another Angle, ( 5. ) where the *Manubrium Malleoli* begins, and where it becomes more round; from whence it gradually Tapers to the Point, being six Lines in length.

The head of the *Incus* is four Lines broad, (Fig. VI. ( 1 ) below which is the Neck or an oblique *Sinus*; ( 2 ) next to that are two *Apophyses*, one on each side. These descending obliquely outwards, and becoming flat, meet in a Point, (Fig. VII. ( 5. ) whence ascending obliquely inward, this Production is join'd to another small round one, like the *Manubrium Malleoli*  $4\frac{1}{2}$  Lines long ( 6. ) This has the fore-mentioned small excavation or half round *Sinus*, ( 7. ) which with the extremity of the *Stapes*, I suppose to have contain'd the *Os quadrangulare*, or rather *Orbiculare*, according to the Figure of the *Sinus*.

The *Stapes* differs much in Figure from the Human one. From its Concave extremity 'tis enlarg'd on each side by two small slender Productions, not unlike the Processes of the *Vertebrae* of some Fishes ( Fig. VI. ( 2 2 ) to which is join'd the *Basis*, ( 3. ) so thin almost as the Scale of a Fish. This was accidentally separated from its two Sides, and remain'd in the *Foramen Ovale*, from whence I pull'd it with a Pin; 'Tis Concave towards the *Stapes*, and Convex toward the *Vestibulum*.

The *Foramen Ovale* lyes so hid and obliquely in the side of the *Cavitas Tympani*, that it could not be delineated in its true Dimensions. Near to it is another hole Oblong and Sharp at both ends, both which give an entry into the *Vestibulum*.

The *Vestibulum* is of an irregular Figure, (Fig. X. ( a ) 'tis for the most part three Lines from the one side to the other, and perforated by eight Orifices, viz. five for the Canals of the *Labyrinth*, (Fig IX. X. ( a )  
one

one for the *Cochlea*, ( *Fig. X. (b)* ) and two for the *Fenestræ* ( *b, c.* )

The *Cochlea* is a long Cavity consisting of three *Gyres* or *Meanders*; ( *Fig. XI. (d e f)* ) Its Orifice where it proceeds from the *Vestibulum* is but small; but it afterwards widens, so that the first course of this Cavity is a third part larger than the second ( *e* ), and proportionally the third is less than the other two ( *f* ), till it terminates in an Orifice ( *g* ) situated in the Top, for receiving a branch of the soft portion of the *Nervus Auditorius*, which accompanies and passes along all its *Gyres*.

The hardness and solidity of the Bone (for which it may be justly called *Os Petrosum* in this Subject) was such that I could not so exactly trace the three Canals or Ducts of the *Labyrinth*, so as to give a true Idea of the manner of their several Turnings. But *Valsalva's* Figures of the Humane Ear directed me so exactly, that I easily found out the several Orifices, and opened them so far as to find out their situation and true Dimensions, by introducing a Hogs bristle, then cutting it off and stretching it out to the Scale. Thus after laying open the two *Foramina* which gave an inlet to the *Vestibulum*, I soon perceiv'd the several Orifices which in so large a Subject were pretty conspicuous. I first turn'd to the one hand and discovered the Duct of the *Cochlea*; this I pursued all along the Protuberance, ( *Fig. III. (d)* ) in doing of which I laid wholly open the *Lesser Duct* of the *Labyrinth*. ( *Fig. IX. X. (d)* ) Then turning up the other side of the Bone, I trac'd the soft Portion of the *Nervus Auditorius* divided into two Branches, one whereof was distributed into the *Cochlea*, and the other to the *Labyrinth*. In filing the Bone a little further, I opened a small part of the *Middle Duct*, and in a short time I discovered the *Ductus Major*;

*Major*; after which I measured their several lengths as is said.

The *Labyrinth* then consists of three *Lineæ Semilunares* or incurvated *Ducts*, whereof the *Major* lyes in that part of the *Processus Petrosus* which regards the seat of the Brain (*b*) This is twenty Lines or one Inch eight Lines long. The *Medius Ductus*, one part whereof regards the Orifice of the *Cochlea*, and the other is common with the *Major* for the space of three Lines; (*e*) this is fifteen Lines or one Inch three Lines long: And the *Minor* which regards the *Cavitas Tympani*, has one Orifice which is near to the *Medius*, were it approaches the *Cochlea*; and the other near to the Orifice of the *Major*. This is one Inch long.

The seventh pair of Nerves called in general the *Nervus Auditorius*, enters the *Processus Petrosus*, and is divided into the hard and soft Portions, as in other Animals. In this Subject I find one Canule entring the Bone from the sides of the Orifice for the *Carotide*

Osteog. Eleph.  
Tab. 3 Fig. III.  
Fig. IV.

Artery, about three Lines diameter, (*e*) (*b*) from thence running forward for the space of one Inch four Lines, then bending downwards one Inch till it meets with the Orifice at the Sides of the *Meatus Auditorius*, by which it pierces the Skull, and passes outward. This Canule, after it is entred the *Processus Petrosus* for the space of eight Lines, communicates with the Orifice which usually enters the foresaid Process from the Base of the Skull; and both these Orifices, after they have accompany'd one another about five Lines, are separated, and the soft Portion penetrates the Bone at two places, as is said.

I have now endeavoured to give such a Description of the *Osseous* or Bony part of the Ear of this stupendious Animal, as I am in hopes may be useful for the  
 \* clearing

clearing up of some *Phænomena* in lesser Subjects. At least we may hereby observe, what a variety of Mechanism the great Author of Nature has thought fit to employ, in the several parts of different *Species* of Animals. Thus both the external Ear of Man, and of the *Elephant* lye flat, as being most convenient: for if they had been Protuberant as in most Quadrupeds, how unsuitable would it have been in Man, who is the most perfect of all Creatures, not upon the account of his Reason alone, but also as he is a Pattern for Beauty and the Symmetry of his Parts; and how unseemly would it have been in the *Elephant*, if his external Ear had stuck out, and been proportional to his other Parts; considering what an extraordinary aspect he makes already by his Trunk and Tusks? But the Ears in these two Subjects differ by the tortuosity of the Cartilage, and oblique *Meatus*, to prevent the injury of the Air, by its immediate access into the inner Ear in Man: whereas in the *Elephant* the external Orifice is fully expos'd to the Air; but then the length of the *Meatus* hinders any more Air than is convenient from arriving at the *Tympanum*. We likewise see in the *Seal* and *Otter*, that those two Amphibious Quadrupeds have no external Ear further protuberant than the other Parts of their Head; for had it been otherwise, their swimming and diving would have been much hindred: But its two sides are so collaps'd, that no Water can enter in when in the Deep, though it can receive sufficient Air when afloat. The cellulous Cavity of the *Tympanum* in the *Elephant*, may well be compar'd to the *Apophyss Mastoides* in Man; and the second Cavity of a plain Surface seems to be Analogous to the Cavous *Mastoides* in *Sheep*, *Cats*, *Dogs*, &c. So that we see that whereas other Animals have but one Cavity for assisting the Vibration of the Air, and continuation of the

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Sound

Sound in the *Tympanum* ; this Animal has two, or a large one with two different Surfaces. The Aqueduct both by its Figure and Position in this Animal doth plainly shew us the Use of it in other Animals, which is to receive the superfluous Humours in the *Tympanum*, and convey them to be discharg'd in the Mouth.

## Explication of the FIGURES.

### Figure I.

- R** Represents the Bony part of the Meatus Auditorius of the Right Ear.
- a The external Orifice of the Meatus Auditorius.
- b The Processus Petrosus.
- c The Orifice where the Nervus Auditorius enters.
- d The Meatus Auditorius.
- e A part of the Laminæ which proceed from it on each side, by which the Cellules betwixt the two Tables of the Scull are form'd; those situated above the Meatus being remov'd.
- f Part of the inner Table of the Scull.
- pened, with other parts of the inner Ear.
- a The ragged part of the Bone from whence the Os Petrosum was separated.
- b The Processus Petrosus opened.
- c The Crena for the Membrana Tympani.
- d The Honey comb Cavity of the Tympanum.
- e Its inner Cavity of a smooth Surface.
- f Its Semicircular or undulated Lines.
- g The Orifice of the Aqueduct.
- h The Orifice of the hard Portion of the Nerve.

### Fig. II.

Represents part of the Meatus Auditorius or

### Fig. III.

Represents the lower Surface of

*of the Os Petrosum, as it was separated from above the Tympanum and other parts of the inner Ear.*

*aa The ragged Margine of the Bone.*

*bb The upper part of the Cavitas Tympani.*

*c The Foramen Ovale.*

*d The Protuberance in which the Labyrinth and Cochlea are lodg'd.*

*e The Orifice of the hard portion of the Nervus Auditorius.*

#### Fig. IV.

*Represents the Malleolus alone in its true dimensions*

*1 The Protuberant Head.*

*2 The Semicircular Sinus betwixt it and the Margin*

*3 The Sinus which receives the head of the Incus.*

*4 The angle below the Sinus for the head of the Incus.*

*5 The angle where the Manubium Malleoli begins.*

*6 The Manubrium Malleoli.*

#### Fig. V.

*Represents the Incus.*

*1 The head of the Incus.*

*2 The Sinus or neck of the Incus.*

*3 Two Apophyses.*

*4 A long protuberance with the Sinus for the Os quadrangulare at its extremity.*

#### Fig. VI.

*Represents the Stapes.*

*1 The small part of the Stapes, where it is articulated with the Incus, with a Sinus at its extremity, being the other half of the Cavity for the Os quadrangulare.*

*2 Two small portions of the Stapes, where it is articulated with the Basis.*

*3 The Basis of the Stapes separated.*

*4 The whole Stapes.*

#### Fig. VII.

*The Malleolus and Incus join'd together, with their lower side turn'd up.*

*1 The Malleolus.*

*2 Its articulation with the Incus.*

*3 The Incus.*

*4 The Manubrium Malleoli.*

*5 A point of the Incus, fram'd by the other two Productions.*

*6 The*



6 *The long protuberance of the Incus.*

7 *The Sinus in the extremity of its long Production.*

*Fig. VIII.*

*The Malleolus, Incus and Stapes articulated together.*

1 *The Incus.*

2 *The Malleolus.*

3 *The Stapes where it shuts the Foramen Ovale.*

*Fig. IX.*

*Represents the upper part of the Lineæ Semilunares, or that side which is towards the passage of the Nervus Auditorius.*

a *The five extremities cut off.*

b *The Linea Semilunaris Major.*

*The Semilunaris Media*

d *The Minor.*

e *The common Canule between the Major and Media.*

*Fig. X.*

*Represents the Cochlea and Labyrinth together.*

a *The Vestibulum.*

b *The Foramen Ovale.*

c *The Foramen Oblongum.*

d *The Linea Semilunaris Minor, which is towards the Cavitas Tympani.*

e *The common Canule to the Major and Media.*

f *The Major.*

g *The Media*

h *The Cochlea.*

*Fig. XI.*

*Represents the Cochlea.*

a *The Vestibulum.*

b *The third Gyre or turning.*

c *The Orifice.*

d *The first Gyre or turning opened.*

e *The second turning.*

g *The Orifice at the top of the Cochlea.*

*F I N I S.*

ERRATA. N<sup>o</sup>. 357. Pag. 847. lin. 22. lege ab b 11'. 32". pag. 885, lin. 27. lege N<sup>o</sup>. 326. 327.

*L O N D O N :*

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Fig. 1,

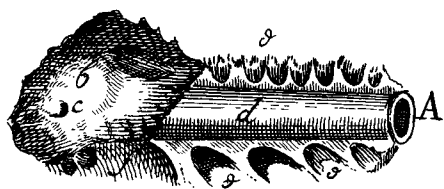


Fig. 11.

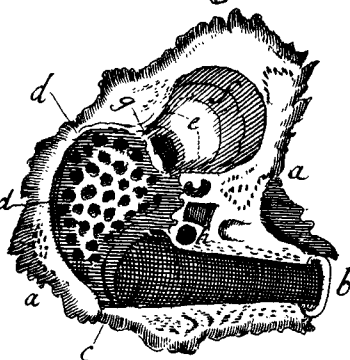


Fig. III

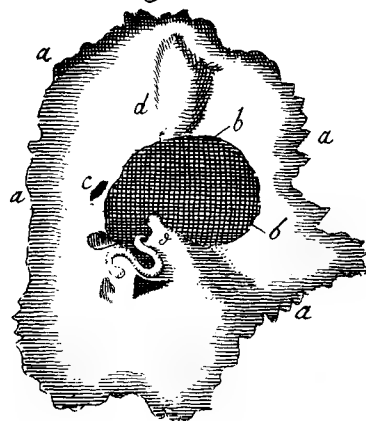


Fig. III



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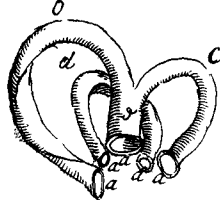
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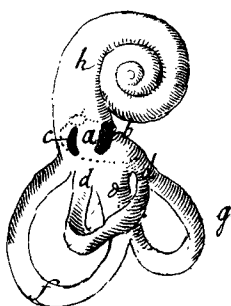


Fig. XI



Fig. 1.

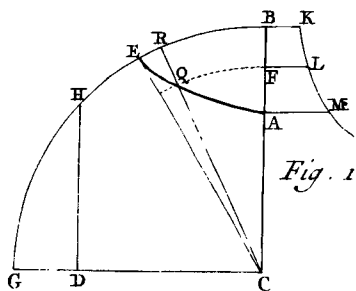
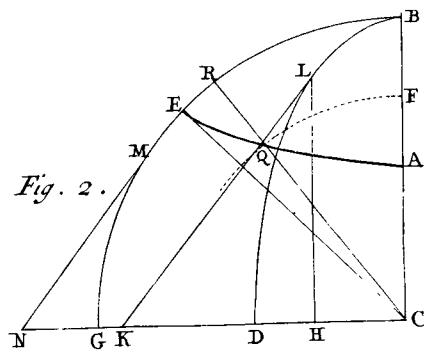


Fig. 2.



# PHILOSOPHICAL TRANSACTIONS.

For the Months of *January* and *February*, 171<sup>18</sup><sub>19</sub>.

## The C O N T E N T S.

- I. **C**URIOUS Observations of the Transit of the Body and Shade of Jupiter's fourth Satellite over the Disque of the Planet. Communicated by the Reverend Mr. James Pound, R. S. S.
- II. A Discourse tending to shew the Situation of the ancient Carteia, and some other Roman Towns near it. By John Conduitt, Esq; Fellow of the Royal Society.
- III. A Letter of M<sup>r</sup> l'Abbé Conti, R. S. S. to the late M. Leibnitz, concerning the dispute about the Invention of the Method of Fluxions, or Differential Method; with M. Leibnitz his Answer thereto.
- IV. *Pars reliqua Dissertationis De Potentiâ Cordis. Authore Jacobo Jurin, M. D. & R. Societatis Soc.*
- V. *Nova Methodus universalis Curvas Omnes cujuscunque Ordinis Mechanice describendi, sola datorum Angulorum & Rectarum ope. Per D. Colin Maclaurin in Collegio Novo Abredonensi Matheseos Professore.*
- VI. Extract of a Letter of the Reverend Mr. William Rice, Rector of Caerleon upon Usk, to Charles Williams Esq; giving an account of an ancient Roman Inscription lately found there. With some Conjectures thereon, by the Reverend Dr. John Harris, R. S. S.

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I. Curious

I. *Curious Observations of the Transit of the Body and Shade of Jupiters Fourth Satellite over the Disque of the Planet. Communicated by the Reverend Mr. James Pound, R.S. S.*

Finding by the Tables of *Jupiter's* Satellites that the Fourth Satellite was to pass over the Disque of *Jupiter* the 16<sup>th</sup> of this present *February*, at Night; we were very desirous to observe the same with the *Hugenian* Telescope, having never before, since I have had the Use of it, been able, by reason of the foulness and inconstancy of the Weather, to make any tolerable Observation of this kind.

At 6<sup>h</sup>  $\frac{1}{4}$  thro' a short Tube, we saw all the 4 Satellites, the 3 outermost on the *East* side of *Jupiter*, and the innermost near the *Western* Limb approaching to an Eclipse. The Fourth at that time was about half a Semidiameter of *Jupiter* from the *Eastern* Limb. Then it proved Cloudy till about 8<sup>h</sup>, at which time (thro' the long Glafs) we could see only the second and third Satellites, the first being behind *Jupiter* in the Shadow, and the fourth entred upon the Disque. We saw at this time a dark Spot, a little *Northward* of the great *Northern* Zone, and near the *Eastern* Limb, where the Satellite was to enter on the Disque; which Spot we took for the Shade of the Satellite. The Clouds then again intercepted our View, till 8<sup>h</sup>. 53'. *Æq. T.* at which time the first Satellite was largely emerged out of the Shadow, and the Spot advanced so far, that we perceived it would arrive at the middle of *Jupiter*, near two Hours sooner than the

the Shade ought to have done by our Computation; but not imagining that this dark Spot could be any thing else but the Shade, we concluded there had been some Error in the Calculation, which we thought to re-examine afterwards. On this presumption we left off observing till  $9^h. 35'$  at which time we were surprized to see a Notch in the Limb of *Jupiter*, near the place where the former Spot entred. This last appearance agreeing well with the time that the Shade of the Satellite ought to have entred the Disque, soon made us alter our former Opinion, and conjecture that this and not the other Spot was the said Shade. At  $9^h. 39^{\frac{1}{2}} \text{ } \text{Æq T.}$  the Notch vanishing, a round, black Spot appeared within the Limb, but in contact with it. At  $9^h. 45'$  we judged the first Spot; and at  $11^h. 45'$  the second, to be in the middle of *Jupiter*.

At  $11^h. 50'$  the first Spot touched the Limb, being within the Disque; soon after which the Limb in that place seem'd a little protuberant. At  $12^h. 5'$  appeared the fourth Satellite just come out of the Disque, and touching the Limb in the place where the Protuberancy was. At  $12^h. 7'$  we could perceive the Satellite separated from the Limb. At  $13^h. 56'$  the second black Spot, still within the Disque, just touched the *Western* Limb; soon after which there appeared a Notch in this part of the Limb, as it did on the other at the coming on of this Spot. At  $14^h. 6'$  the Spot was all gone off, and the Limb appeared clear and entire. The first Spot, when in the middle of *Jupiter*, was almost as black as the second when near the Limb, but somewhat less and a little more *Northerly*.

At the time that the first Spot was in the middle of the Disque, the three innermost Satellites appeared

to the *East* of *Jupiter*; the first (as aforesaid) having lately emerged out of the Shadow; the second being almost at its greatest distance; and the third having passed the Axis of the Shade about twelve Hours before, and appearing at this time about three Diameters of *Jupiter* from his Limb. The times that these Spots arrived at the middle of the Disque are agreeable to the times found by Calculation, in which the fourth Satellite and its Shade ought to have appeared there. From all which 'tis very plain, that the first of these Spots was the fourth Satellite itself, and the second its Shadow.

We have seen the first and second Satellites appearing not as dark Spots, but as bright ones (somewhat different from the light of *Jupiter*) for some little time after they entred his Disque, but as they approached nearer the Middle we lost sight of them. And we have frequently observed that the same Satellites appear brighter at some times than at others; and that when one of them hath shined with its utmost Splendour, the Light of another hath been considerably diminished. From whence 'tis very probable at least, not only that the Satellites revolve upon their proper Axes, but also that some parts of their Surfaces do very faintly (if at all) reflect the Solar Rays to us.

All which hath for some time since been observed and taken notice of by Mess. *Cassini* and *Miraldi*, as may be seen in the *Memoirs* of the *Academie Royale*, for the Years 1707 and 1714.

II. *A Discourse tending to shew the Situation of the ancient Carteia, and some other Roman Towns near it. By John Conduitt Esq; Fellow of the Royal Society.*

**A**Bout four *English* Miles *N.W.* from *Gibraltar*, at the end of the Bay, there are considerable Ruins. The place is called at present *Rocadillo*, and consists of a few Huts, and a Modern Square Tower, which appears to have been raised on the Foundation of a much greater Pile. The Walls of the old City are very easy to be traced. They seem to have been about two *English* Miles in Circumference, and were built upon the Brow of a rising Ground. The space within is covered with Ruins, among which are a great many pieces of very fine Marble well wrought; and innumerable fragments of Vessels of that kind of red Earthen Ware, which *Ambrosio Morales* in the first Chapter of his *Discurso de las antiguedades de las ciudades de Espanna*, lays down for a certain mark of a *Roman* City, and takes to have been a Composition of the Clay of *Saguntum*, often mentioned among the *Romans*.

*Ficta Saguntino pocula malo luto.* Mar. Lib. VIII. Ep. 6.

*Sume Saguntino pocula ficta luto.* Lib. XIV. Ep. 108.

There are remains of a rude Semicircular Building, raised on Arches, which descends gradually into an Area, and seems to have been a kind of Theatre. I brought away with me a Marble Pedestal of a Statue, dug up near to the Square Tower. The Marks where

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the Feet and the extremities of the Drapery were fastened to it, are still to be seen, and the following Letters finely cut V A R I A M A R C E. It was given me by the owner of the Ground, who said he had read upon it formerly three other Letters L L A since broken off. There are other Inscriptions, but so Defaced and ill Cut, that they do not deserve a particular mention. I have a considerable number of Medals, that were found among these Ruins; most of them have a *Caput turritum* with C A R T E I A in very legible Characters. The Reverse is generally a *Fish*, a *Neptune*, or a *Rudder*. Towards the *West* there is an easy Descent to the River *Guadarranque*, which takes its Source at *Castellar*, about four Leagues in the Country, and is very deep at *Rocadillo*. There is a Bar where the River falls into the Bay; but it does not hinder the entrance of Vessels of 15 Tun, to load Charcoal and other necessaries, that are Shipt off from thence for *Centa*. Along the side of the River there is still a great deal of Stone Work and visible remains of an Ancient Key. At a small distance to the East, upon an Eminence there are considerable ruins of a Square Castle, which appears to have been an ancient Building of very great strength. The Country People now call it *Castillon* but the *Corrigidor* of that District told me he remember'd it called *Torre Cartagena*. The Situation agrees exactly with the Tower of that Name, mentioned in the 274<sup>th</sup> and 316<sup>th</sup> Chapters of the Chronicle of *Alphonso XI* of *Castile*, A Book of great Authority among the *Spaniards*, who are generally of Opinion that it was formed upon the Memoirs of *Fernando Nunnez de Valladolid* a Favourite and Minister of that King, tho' it goes under the name of another Person.



All the *Spaniards* who live about the Ruins I have been describing, say they are the remains of a City of the *Gentiles* called *Cartago*. The corruption of *Carteia* into a name so much more talked of, might easily happen in an Oral Tradition of so many Years; and I cannot help thinking that, where other Circumstances concur, an account deliver'd down from Father to Son is an evidence not to be slighted, in matters of so much obscurity.

Frequent mention is made of *Carteia* by the Ancient Geographers and Historians. I build so much on two Passages of *Livy*, that I am obliged to insert them at length. The first is Lib. XXVIII. C. 30. ( *Livy* does not mention from what Port *Lælius* sailed for *Carteia*, but by what goes before, it seems to have been from *Cartagena*. at that time *Scipio's* Head Quarters) *Lælius interim, freto in Oceanum evectus, ad Carteiam classe accessit. (Urbs ea in orâ Oceani sita est, ubi primum è faucibus angustis panditur mare). Gades sine certamine proditiōne recipiendi (ultrò, qui eam rem pollicerentur, in castra Romana pervenientibus) spes sicut antea dictum est, fuerat. Sed patefacta immatura proditiō est, comprehensosque omnes Mago Adherbali Prætori Carthaginem devehendos tradit. Adherbal, Conjuratis in quinqueremem impositis, præmissæque cæ, quia tardior quam triremis erat, ipse cum octo triremibus modico intervallo sequitur. Jam fretum intrabat quinqueremis, cum Lælius & ipse in quinquere-mi, è portu Carteiæ, sequentibus septem triremibus, evectus, in Adherbalem ac triremes invehitur; quinqueremem satis credens deprehensam rapido in freto, in adversum æstum reciprocari non posse. Pœnus, in re subitâ parumper incertus, trepidavit utrum quinqueremem sequeretur, an in hostes rostra converteret. Ipsa cunctatio facultatem detrectanda pugna ademit: jam enim sub iclû teli erant, & undique instabant hostes. Æstus quocque arbitrium moderan-*

*di naves ademerat; neque erat navali pugna similis, quippe ubi nihil voluntarium, nihil artis aut consilii esset. Una natura freti aestusque totius certaminis potens, suis, alienis navibus, nequicquam remigio in contrarium tendentes invocabat; ut fugientem videres retro vortice intortam victricibus illatam, & sequentem, si in contrarium tractum inclisset maris, fugientis modo sese avertentem. Jam in ipsâ pugna hæc, cum infesto rostro peteret hostium navem, obliqua ipsa ictum alterius rostri accipiebat: illa, cum transversa objiceretur hosti, repente intorta in proram circumgebatur.*

The other Passage is Lib. XLIII. C. 3. *Et alia novi generis hominum legatio ex Hispaniâ venit: Ex militibus Romanis & ex Hispanis mulieribus, cum quibus connubium non esset, natos se memorantes, supra quatuor millia hominum, orabant ut sibi oppidum in quo habitarent daretur. Senatus decrevit, uti nomina sua apud L. Canuleium profiterentur, eorumque siquos manumississet, eos Carteiam ad Oceanum deduci placere. Qui Carteiensium domi manere vellent, potestatem fore uti numero colonorum essent, agro assignato. Latinam eam coloniam fuisse, Libertinorumque appellari.*

The best Spanish Authors, and Ortelius and Cellarius trusting to them, take this *Carteia* of *Livy* to be different from that which was the next to *Calpe*, and place it generally about *Conil*. *Rodrigo Caro* in his *Convento Juridico de Sevilla* C. 24. applies the *Carteia* in the XLIII Book of *Livy* to *Rosadillo*, and in Cap. 74. to *Carteia* near *Lepe*. It is surprizing he takes no notice of the Passage in the XLVIII Book. For the particular mention of *ad Oceanum*, and *Urbs ea in ora Oceani sita est*, implies they both relate to the same place; perhaps it was because he could not reconcile it with his *Carteia* near *Lepe*. *Cellarius* makes *Beppo* this *Carteia* of *Livy*. L. 2. c. 1, *Beppo, quæ videtur Carteia Livii esse, extra fretum*

*fretum & columnas posita.* *Aliam pro Livio Carteiam non invenio*; tho' in all the ancient Geographers *Besippo* is mentioned by it self as a distant Town I am so far from seeing any necessity of erecting a new *Carteia* in the Ocean for these Passages in *Livy*, that I take that in Lib. XXVIII. to be rather a proof that the City there mentioned, stood at *Rocadillo*. It certainly agrees much better with that Situation than with *Conil* or *Carteia* near *Lepe*. It is not to be reconciled with the latter, because that lies *North West* of *Cadiz*, from whence *Adherbal* set out for *Carthage*, and is a good way up the Country, on the side of a River, and not *in ora Oceani*. Neither can *Conil* be said properly to be Situated *Ubi primum è faucibus angustis panditur mare*; for the Sea widens considerably before it reaches the Capes *Spartel* and *Trafalgar*, and becomes an Ocean where that Town stands. It is observable that *Mela* applies words of the same import with those of *Livy* to the Sea between *Calpe* and *Abila*. *Barbesul*; *Aperit deinde angustissimum pelagus.* There is no Harbour at *Conil*, or any other place between Cape *Trafalgar* and *Cadiz*. If the *Carthaginian Quinqueremis* had only been going into (*intrabat*) the Mouth of the Streights between Capes *Spartel* and *Trafalgar*, *Laelius* could not have believed it *satis deprehensam rapido in freto, in adversum astum reciprocari non posse*, for there is no such strong Current there; and the action between him and *Adherbal's Triremes*, which were at some distance behind the *Quinqueremis*, must have happened *Westward* of those Capes; which is inconsistent with the description *Livy* gives of it; because in that part of the Ocean there are none of those Eddies, that appear to have had so particular an effect on both the Fleets, during the Engagement, and are peculiar to the Middle of the Gut.

This

This general mistake seems to have been occasioned by giving too easily into the opinion, that *Livy* understood by the *Fretum* all the Sea between the Capes *Spartel* and *Trafalgar*, and the Rock of *Gibraltar* and *Apes-Hill*; when it is more probable that he termed strictly so only the narrowest Part, which was generally reckoned to be between the two latter : *Mela. Proxima Africa & Europæ littora montes efficiunt Caipe & Abila. Pliny* takes *Meſſaria* to be nearest to *Africk*, and therefore places there the *Fretum ex Atlantico mari Lib. 3.* which is an argument his *Fretum* was not the same with our *Stteights*, and that he carried the Atlantick Ocean much farther *East* than the Capes *Spartel* and *Tre-falgar*.

Other Authors seem to make the Pillars of *Hercules* the Boundary of the Mediterranean and the Ocean. *Marcianus Heracleotis.* Ἐνταῦθα πέρας ἔχῃ τῆς Βαλκῆς Ἰσπανίας τὸ μέρ<sup>ος</sup> τὸ παρῆγον πᾶρ ἐκείνης πᾶς θαλάσσης πᾶς περὶ τὸν Ἡράκλειον πορθμὸν πυργανέας, τὴν π καὶ ἡμᾶς ἔ τὴν ἔξω, τῷτ ἔσι τὸν Ωκεανόν. *Hic finem habet Hispania Betica pars contingens utraque maria quæ circa fretum Herculeum, tam mare nostrum quam mare exterius, h. e. Oceanum.* Τῆς μὲν Βαλκῆς τὸ πλεῖστον ἀπὸ τῆς καὶ ἡμᾶς καίται θαλάσσης, πρὸ Ἡρακλείων ἐπὶ τὸς σηλῶν, μέρος δὲ π πρὸ τὸν δυτικόν Ωκεανόν *Betica quidem pars maxima pratenditur nostro mari, Hercules intra columnas, pars vero quædam occidentali Oceano.*

*Polybius l. III.* Καλεῖται δὲ τὸ μὲν πρὸ τὴν καὶ ἡμᾶς παρῆγον ἕως Ἡρακλείων σηλῶν, Ἰβηρία το δὲ πρὸ τὴν ἔξω ἔ μεγάλην προσωρορευμένην κεινὴν μὲν ἀνομασίαν ἔχει, διὰ τὸ προσωφάτως καποπτεύεσθαι *Quæ porrigitur secundum mare nostrum portio ad columnas usque Herculis Iberia nominatur; quæ secundum mare externum quod & magnum appellatur, communem appellationem nondum invenit, quia non diu est cum fuit explorata.*

*Appian*

*Appian L. II.* Ἐμφυλ. πόλεμι παρὰ σήλας παρὰ Ἡρακλέους τὸν ὠκεανὸν ἐπέεον. *Trajecto ad Columnas Herculis Oceano.*

*Florus Lib. IV. C. 2.* In ipso ostio Oceani Varus Didianusque legati conflixere; sed acrius fuit cum ipso mari, quam inter se navibus bellum: Siquidem velut furorem civium castigaret Oceanus, utramque classem naufragio cecidit. Quinam ille horror, cum eodem tempore fluctus, procellæ, viri, naves, armamenta confligerent? Adde præter ipsius formidinem, vergentia in unum hinc Hispaniæ inde Mauritaniam littora; Mare & intestinum & externum, imminentesque Herculis speculas; cum omnia undique simul pralio & tempestate sevirerent. Here the Pillars of Hercules are made the very Mouth of the Ocean. If you understand the *Fretum* of *Livy* in this Sense, and reckon it to signify only the Sea between *Calpe* and *Abila*, and the Ocean to begin from thence Westward, the Passage in the 28th Book is an accurate description of *Rocadillo*. *Laelius* interim freto in Oceanum evectus ad Carteiam classe accessit. Urbs ea in ora Oceani sita est, ubi primum è faucibus angustis panditur mare. And allowing *Laelius* to set out against *Adherbal* from thence, every circumstance mentioned by *Livy* is so easy to be accounted for, that it is needless to make Application. A Passage in *Lio Cassius* Lib. XLIII. induces me to believe the Vessels anchored in the *Guadarranque*, and that that River. and not the Bay was properly *Portus Carteie* "Οὐαρ.Θ. δὲ ὑπὸ τῷ Διδίῳ πρὸς Κραντίαν ἐναυκρατῆσθαι ἔειπε μὴ πορθηταφύγων εἰς τὴν γῆν, ἀγκυρας εἰς τὸ σωμα. ὃ λιμέν.Θ. ἄλλας πρὸς ἄλλας πορσευεβεβλήκει. ἔπειτα αὐτὰς οἱ πορῶται τῶν διωκόντων σφᾶς ὥσπερ πρὸς ἔρμα ἐπ' αὐτὰς, πᾶν ἂν τὸ ναυικὸν ἀπολωλέκει. Varus vero à Didio apud Crantionem navalī pralio superatus in terram evasit, conjecisque in introitum portus anchoris, ita ut una ab aliā teneretur, cum ad eas, tanquam ad septum quoddam, prima insequentium naves

*naves offendissent, periculum totius classis amittenda declinavit.* This cannot be understood of the Bay, because that is three Leagues over at the narrowest part, and much too deep for a work of such a Nature, which might easily have been effected upon the Bar of the River *Guadarranque*.

There is no room to doubt of the emendation *Juis Nunnes*, in his *Hispanica*, has made here of *Καρμία* for *Κεαντία*; for no ancient Author mentions any other Town or Harbour thereabouts of a name like that; and *Carteia* was the place which held out the longest for the younger *Pompey*, and where he kept his Fleets.

*Florus* in the Passage I have already quoted, relating the same Action between *Didius* and *Varus*, represents in very lively Colours, the very Scene near *Rocadillo*. *Adde situs ipsius formidinem, vergentia in unum hinc Hispaniæ inde Mauritaniae littora; mare intestinum & externum, imminentesque Herculis speculas &c.*

*Hirtius*, in the latter part of his Book *de bello Hispanico*, says *Cn Pompeius ad navale praesidium parte alterâ contendit Carteiam, quod Oppidum abest à Corduba millia passuum CLXX.* which distance, as well as the circumstance of *navale praesidium*, agrees with the Situation of *Rocadillo*. The ancient Geographers place *Carteia* next to *Calpe* Westward. *Pomponius Mela*, after having given us a perfect Picture of *Calpe*, and described those lasting Marks, in which so many Centuries have made no alteration, says—*Sinus ultra est, in eoque Carteia. Strabo L III. Ἐνταῦθα δὴ ὄρεσσι τῇ Ἰβήρων ἡ Καλπή, &c. καὶ πρὸς αὐτὸ Καλπὴ πόλις ἐν πετρεῶνται σεδίοις, ἀξιόλογος ἔ παλαιὰ, ναυσταθμός ποτε γνομίνη τῇ Ἰβήρων. Ἐνιοὶ δὲ ἔ Ἡρακλῆος κλισμα λέγουσιν αὐτὴν, ὡν ἐστὶ ἔ Τιμωδότης. ὅς φησι ἔ Ἡρακλείαν ὀνομάζεσθαι τὸ παλαιὸν, δέικνυσθαι τε μέγαν περὶ βολὸν ἔ νεωταίους. Ibi mons Hispanorum est Calpe, &c. ἐξ ad XL inde Stadia Urbs Calpe vetust.*

*vetusta & memorabilis, olim Statio navibus Hispanorum. Hanc ab Hercule quidam conditam aiunt, inter quos est Timosthenes, qui eam antiquitus Heracleam fuisse appellatam refert, ostendique adhuc magnum murorum circuitum & Navalia. Casaubon, in his Notes on this Passage is of Opinion it should be Καρμία πόλις. Legendum censeo Καρμία πόλις, nam eam urbem hic intelligi res ipsa docet; & ex eo colligi potest, quod toties eam infra nominans nihil tamen de ejus situ alibi dixisse reperitur. At Calpen Urbem nemini Veterum ne nominatam quidem reperio.*

*Marcianus Heracleotes makes Carteia 50 Stadia from Calpe. Either of these Distances agrees with Rocadillo, according to the part of the Rock from which they reckon; for it is above six Miles from Europa Point to Rocadillo.*

*Bochart in his Geographia Sacra Lib. I. Cap. 34. strengthens Casaubons Opinion. Nec frustra Heraclea Carteiæ fuisse vetus nomen, tanquam ab Hercule conditore. Herculem enim suum Phœnices Μέλκαρδον appellabant. Philo Biblius ex Sanchoniathone apud Eusebium L. I. Preparat. τῷδε Δημαρῶντι γίνεται Μέλκαρθος ὁ καὶ Ἑρακλῆς. Ex Demarunte autem natus est Melcarthus qui & Hercules. Μέλκαρδος autem est מלך קרחה Melech Kartha. Rex Urbis, i. e. Tyri. Idem Græcis Melicertes sive Palæmon Maris Deus, quem Cadmi nepotem esse fingunt. Hinc Hesychius rursus Μάλικα τὸν Ἑρακλέα Ἀμαθῦσιος. Omnino igitur ex Melcartho, vel מלך קרחה Melech Kartha. Urbs quam ad Calpen condidit Hercules Phœnicus, primo Melcartheia vocata est, Melech Karthiia, quasi Ἑρακλέαν dixeris; deinde per Apharesin Cartheia vel Carteia. Apud Hebræos frequens est hæc Apharesis in nominibus locorum compositis. Tale Sittim pro Abel-Sittim, Salem pro Jerusalem, &c.*

*I have some Medals that were dug up at Rocadillo, with the Head and Club of Hercules upon them;*

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which

which seem in some measure, to support that great Man's Assertion. Upon the Reverse are Tunny Fishes, which according to *Strabo* and *Pliny* abounded formerly near *Carteia*, and are still taken in great quantities near the Shoar of the East Sea, at a small distance from *Rocadillo*.

*Bernardo Aldrete* an Author of such Weight, that *Bochart* does not disdain to copy him on several occasions, in the second Book and second Chapter of his *Antiguedades de Espanna*, accounts for the Addition of *eia* to *Cartha*; which in the *Syriack* and *Chaldean* signifies *Pulcher*, *Formosus*, and was affixed to the Name of this City to distinguish it from the *Cartha* in *Syria*, mentioned in the 21<sup>st</sup> Chapter and 34<sup>th</sup> Verse of *Josbuc*.

By all accounts, the *Phœnicians* founded most of the Cities on this Coast, and probably *Carteia* was one of their earliest Settlements; for it lies very near *Africk*, in a most inviting Situation, having on one side a Bay, and on the other a River, which waters a rich Country. Its height gave it strength and a very beautiful Prospect; circumstances which seem to justify *Aldrete's* interpretation of the latter part of it's name.

In the Itinerary of *Antoninus*, it is *Calpe - Carteam*, not *tanquam duæ urbes diversæ*, as *Casaubon* intimates in his Notes on the third Book of *Strabo*, for then it would be *Calpen Carteam*; nor, according to *Surita's* Comment on that part of the Itinerary, *ut significet non rectâ iter ex Suel Carteam deduci, sed paululum ad Calpen deflecti*; because *Calpe* stands at the end of a narrow neck of Land, which projects to the Southward a great way from the rest of the Continent; and consequently is quite out of the Road from *Suel* to any other place Westward of it; probably *Calpe - Carteia* is for *Carteia ad Calpen*, to distinguish it from the other *Carteia* in *Celiberia*, mentioned in the 21<sup>st</sup> Book and



5th Chapter of *Livy*: for, as *Caro* observes, there is no necessity for the alteration *Sigonius* has made in that passage of *Althæa* for *Carteia*, from the Text of *Polybius*; because *Livy* never mentions the other *Carteia* without adding *ad Oceanum*, *Urbs ea in ora Oceani sita est*; which distinction were needless, had there been only one City of that Name. *Strabo* in his third Book mentions a City called *Καρταίας*, and places it near *Saguntum*, which is agreeable to the Situation given this *Carteia* by *Livy*.

I am very much surprized that *Mariana*, and several others, should take the present *Gibraltar* to have been the ancient *Heraclea*; when neither *Pliny*, who resided so long in those Parts, *Mela* who was born there, nor any ancient Geographer or Historian that I have met with, makes the least mention of such a City thereabouts, except *Strabo*; and he places it 40 Stadia from *Calpe*, at the Foot of which *Gibraltar* is situated. The *Spanish* Historians give good ground to believe there was no Town upon that Mountain till the *Moors* invaded *Spain* under *Tariff*, who gave it the name it has retained ever since. I shall not enter into the detail of the reasons of those Authors who place *Carteia* at *Tarifa* or *Algezira*: the true one seems to have been their not knowing any other place which agreed better with the old accounts of *Carteia*, or where the ruins of a City, which made so great a Figure, could be buried; the common practice of Authors who describe places they have not seen. This appears to have been the case of most of those, especially *Mariana*; who, had he been in these Parts, would not have been guilty of the oversight he has committed Lib. XVI. C. 9. where he places two Bays in the *Streights*, one at *Gibraltar*, and the other at *Tarifa*; which error he was probably led into (as it often happens) by another.

For, giving into the Opinion that *Tarifa* was the ancient *Carteia*, and finding that City placed in a Bay by *Mela*, he concluded there must be one at *Tarifa*, which is an open Road, and so much exposed, that in the least bad Weather, the smallest Vessels must be haul'd ashore. Which Circumstance alone is a sufficient proof of its not being *Carteia*, by all accounts, a famous Harbour.

Tho' there are very great Ruins at *Algezeira*, they are not such as give any room to believe they are the remains of a *Roman* City. For neither pieces of Marble, nor Inscriptions are found there, nor any *Roman* Coins. The Circumstance of *Varus* his shutting up the Mouth of the Harbour of *Carteia*, and the distance of 40 or 50 *Stadia* from *Calpe*, are not applicable, either to *Tarifa* or *Algezeira*; and if one of those Towns was *Carteia*, to what City belong those Ruins I have been describing? since all the ancient Geographers make *Carteia* not only the nearest Town to *Calpe*, but the only one in that Bay. There is better ground to believe *Tarifa* stands on the Ruins of an other Town, as I shall endeavour to shew presently.

But before I proceed to a Description of the Coast, it may not be improper to mention some Ruins I saw at *Ximena*; an inland Town, about five Leagues North from *Gibraltar*, situated on a Rocky Hill, at the bottom of which to the Eastward is a very plentiful Country, washed by the *Josgarganta*, a small Branch of the River *Guadiaro*. On the top of the Hill is the old Town, which by the Arches and Vaults, appears to have been built by the *Moors*. On the right-hand Corner of the second Gate of it, there is a course Stone with Mouldings on the Edges, which has the following Inscription.

L. H E-

( 915 )

L. HERENNIO HE  
RENNIANO  
L. CORNELIVS HEREN  
NIVS RVSTICVS  
NEPOSEX TESTA  
MENTO POSVIT  
NONIS MARTIIS  
SEX. QVINTILIO CON  
DIANO SEX. QVIN  
TILIO MAXIMO COSS.

*Rodrigo Caro* in his *Convento Juridica de Sevilla* C. 13 says he saw the beginning of this Inscription in *Bejer de la miel*; but when I was in that Town, I was informed by a very intelligent Person, that there is no *Roman* Inscription in any part of it. The Author of *Cádiz el Emporio del Orbe*, when he inserts this inscription, makes it SEXOVINTILIO CONDIMIO; But the Dash of the Q is very plain, and the other word seems rather CONDIANO. The *Latin Fasti* in A. U. C. 903. place Consuls

SEX. QUINTILIUS GORDIANVS  
SEX. QUINTILIUS MAXIMUS.

But the very learned Dr. *Bentley* has observed to me that the *Greek Fasti* and *Dio* call him Κορδινανός, which reading is confirmed by this Inscription.

I have brought with me from this Town a piece of Marble with the following Words upon it.

AVCTINVS CLEMEN  
TIS SIBI  
ET SVIS BRITTÆ  
MATER AN LX  
H.S.E. SIT T.T.LEVIS.

I saw

I saw another on the Wall of the great Church which seems to have been the Base of a Statue; the Inscription is as follows.

RESPUBLICA OBEN  
SISE..LO DATO  
DEDI...VIT CVRAT  
LIBE..OR H..REN  
NIO RVSTICO H.M.  
SINILO RESTITVTO  
II VIR.

The manner in which the *Moors* have placed these Inscriptions plainly shews the little value they set upon them, and there is so great a plenty of Stone on the Rock where *Ximena* stands, that it is not to be thought they would fetch them for such an use, from any distant place; which induces me to believe a *Roman Town* formerly stood there called O B A.

I do not find any Town of that name in the ancient Authors. *Strabo* L. III. mentions Σόροβα Μαίνοβα ἡ ἄλλα γὰρ λέγεται, which may possibly comprehend *Oba*. The *Geographia Nabienfis*, in the fourth *Clima*, makes a Town called *Rotban*, the first Station from *Algezeira* to *Seville*, which perhaps may have been this *Oba*; for it is about a Days journey from *Algezeira*, and in the direct Road from thence to *Seville*.

*Mariana* places Lib. III. C. 2. the Cave where *Crassus* hid himself, near *Ximena*; the Marks of it, given by *Plutarch*, are common to most others. I went three Leagues in search of it; but the Country People having a notion that there is a Treasure in it, and not being to be persuaded that I would take so much Pains out of pure Curiosity, would not shew me the Way, tho' they acknowledged there were several such Caves thereabouts. I cannot help taking notice of one very odd

odd tho' trifling circumstance. The name of the Person who owns the Land where those Caves are, is *Pacheco*, which is very near the same with that of the *Spaniard*, who is said by *Plutarch* to have entertained *Crassus* so courteously, Παναγός. *Hirtius* in the beginning of his Book *de bello Hispanico* mentions a *Spaniard* of Note, in provinciâ *Beticâ*, called *Paticcus*. *Quibus prefecit hominem ejus provincie notum & non parum scientem*, *L. Julium Paticcum*, which was probably the Roman Name; and therefore I am surprized the *Latin* Translator of *Plutarch* makes it *Pacianus*.

Most of the antient Geographers describe the Coast Westward of *Carteia* in the following manner. *Julia Traducta*, *Mellaria*, *Balo fluvius & oppidum*, *Portus Bassippo*, *Promontorium Junonis*, &c. The Itinerary of *Antoninus*, makes no mention of *Julia Traducta*, and *Pliny* places it on the *African Coast*, which *Hardouin* endeavours to account for Pag. 227. in his *Nummi Illustrati*. *Strabo* calls it *Juliam Jozam*, which as *Bochart* observes Lib. I. C. 24. signifies the same in the *Phanician Language* as *Traductam* in the *Latin*. *Ptolomy* calls it *Transducta*. He places *Barbesula* between that and *Carteia*. But all the other old Geographers put both the Town and River of that Name Eastward of *Calpe*. I saw some Ruins on the East side of the River *Guadiaro*, four Leagues East of *Gibraltar*; which I take to be the remains of the ancient *Barbesula*. For I find in the *Cadiz Emporio del Orbe*, mention made of two pieces of Marble, brought from thence to *Gibraltar*; on one of which was M M B A R B E S V L A N I. I was credibly informed they were used for the Fountain on the Parade. The Letters probably were either sawed off, or turned inwards; for they do not appear. This *Barbesula* is probably the *Barbariana* placed in the Itinerary X. M. P. East from *Carteia*.

*Pomponius Mela*, who was born in those Parts, and therefore is most to be depended on, gives the following account of the Coast, according to the Edition of *Gronovius*. *Sinus ultra est, in eoque Carteia, ut quidam putant, aliquando Tartessus, & quam transvecti ex Africâ Phænices habitant; atque unde nos sumus, Tingentera. Tum Mellaria & Bælo, & Bæsippon usque ad Junonis promontorium oram freti occupat.* The Text of *Mela* in this place has occasioned great disputes among the Learned. *Casaubon* in his Notes upon *Strabo*, says, *lego autem—atque unde nos sumus Tingi contraria Mellaria, aut Tingi è regione sita Mellaria. Nam Tingis factam hic à Melâ mentionem mihi est persuasissimum; primum quidem veterem lectionem spectanti, quæ est, ut dixi, Cingenteratum; aut etiam ut in suis libris doctissimus Elias Vinctus reperit Tingentera; ut jam de eo dubitari non possit. Deinde autem video morem Melæ hunc esse, ut locorum in alterâ orâ oppositorum mentionem faciat. Sic alibi: Majorem Sabæi tenent partem, ostio proximam, & Carmanis contrariam Macæ. Nec moveri quisquam debet quod alii Tingin Bæloni non Mellariæ faciunt contrariam. Nam Bælo & Mellaria ita sunt vicinæ, ut mirari hoc nemo debeat. Salmasius*, whose opinion is approved by *Bochart*, makes it *Tingis altera, tum Mellaria, &c.* and takes the preceding *transvecti* to denote *Julia Traducta*. *Casaubon* seems to have been once of the same Opinion. *Sed a Strabone stare Ptolemæus videtur, qui in hac Hispaniæ orâ oppidum quoddam memorat cui nomen Transducta, in quod scilicet collocati fuerint isti, de quibus nunc loquitur Strabo; & de quibus dubitavi aliquando, an hæc Melæ verba essent accipienda, In eoque Carteia, ut quidam putant, aliquando Tartessus, & quam transvecti ex Africâ Phænices habitant. Nam videbatur satis aperte Transductam Ptolemæi ὁψηλάει. Nunc iis assentior qui ad Carteiam ea referunt.* The opinion of

\* *Salma*

*Salmasius* seems to be the most probable; for *Bælo* and not *Julia Traducta* is said to be over against *Tingis*. *Marcianus Heracleotes* makes the two former about 250 Stadia distant from one another, and *Mellaria* is generally placed between them; therefore they could not be so near one another as *Casaubon* insinuates. Tho' *Carteia* was originally founded by the *Phœnicians*, it had been erected into a *Roman Colony* long before *Mela's* time, and therefore he could not very properly say *Carteia, quam Phœnices habitant*; and had he intended to take notice of the Founders of that City, it is probable that one whose Style is so pure and accurate, would have made use of another word, or at least another Tense. Besides, if *Julia Traducta*, according to *Casaubon*, is not meant by that passage, it must have been entirely omitted by *Mela*; which is very unlikely, considering he was Born in or near it; and that it is mentioned by *Strabo*, who lived before him, and *Ptolemy* and several others who were after him; and appears to have been remaining at the time the *Vandals* were in possession of *Spain*; for *Greg. Turon. Lib. II. says Prosequentibus Alamannis usque ad Traductam, transito mari, Vandali per totam Africam ac Mauritaniam sunt dispersi*. The Letters of *Tingi altera* come nearer the *Tingentera* of *Elias Vinetus*, and the *Tinge Hiera* of *Gronovius*, than *Casaubons Tingi contraria* or *Tingi è regione sita*. The *Ἔ* and the *atque*, by making the stop at *Tartessus* instead of *Habitant*, may very well relate to the same place; and it is not improbable that *Mela* was desirous to illustrate the obscure place of his Birth by a Periphrasis, and a name of some *Eclat*; tho' it has happened, the method he took to do Honour to it, has been the occasion, that we are in doubt even of its Name.

I met with two Medals of *Julia Traducta* among the Brass *Spanish* Coins; but as I cannot ascertain where they were found, I will not pretend to form from thence any judgment of the situation of the Town to which they belong. But I presume in matters so dark, a conjecture may be offered. It does not seem very improbable, that *Julia Traducta* stood where *Tarifa* is at present. The *Spanish* Authors reckon that Town to have been built by *Tarif* at his second coming to *Spain*. I cannot see what could invite him to settle on a Spot which has neither the convenience of a River, nor a Harbour, and is commanded by a rising Ground; unless he found some Tenements standing, or Ruins to serve for Materials to Build. I have several *Roman* Coins that were found there after great Rains, in the Common Sewer; which is some slight inducement to believe it was formerly a *Roman* Town.

About a League and half to the *West* of *Tarifa*, is a place which goes now by the name of *Val de Vaca*. The Country People have a Tradition among them, that it was once a considerable Town, since swallowed up by the Sea. There is a small Brook called *el Arroyo de Juan Francisco*, which serves to turn some Mills, that a Priest of that Name was encouraged to build there, by finding an antient Stone Channel for the Water. I saw some other small Ruins, and was credibly assured there are visible remains of an old Town a good way under Water. There is a Shoal almost off this place, that runs pretty far in the Sea, on which a *Hamburgher* was lost some Years ago. Perhaps *Mellaria* stood hereabouts.

Wherever it was, the Ruins of it must be a considerable way in the Sea, if credit is to be given to *Pliny*, who upon the Testimony of one Born there, reckons only five Miles from thence to *Afric*. Lib. III.  
whereas



whereas it is at present five Leagues over at the narrow Part. *Casaubon* is mistaken in that Note on *Strabo* L. II. where he says, *At Maris Mediterranei ostium vix LXX Stadia latum est* ἢ σπυρίων.

I cannot help observing that the best Hony in all *Spain* is made in these Parts, and that the same cause to which the ancient *Mellaria* ow'd its Name, still subsists, and has given a modern Appellation to several places hereabouts, as *Playa de Orimel*, *Rio de la Miel*, *Bejer de la Miel*. The latter of these is generally reckoned by the *Spaniards* to be the old *Mellaria*, for no other reason, that I can see, but the Name. For it is at least two Leagues from the Coast of the Streights, and, by what I could judge when I was on the Spot, as near the Ocean, and therefore may as well be ascribed to the one as the other. Whereas *Mellaria*, according to all the old Geographers, was situated on the Sea side in the Streights, and is reckoned by *Pliny* the nearest Town to *Afric*; a plain proof that it was not what is now *Bejer de la Miel*.

About a League and half further *West*, in a small Bay, there are very great Ruins, which appear evidently to be the remains of a *Roman* Town. A League *Eastward* from that place, upon an Eminence, are to be seen the Quarries from which the Stone was fetched for building it; and all the way from thence are large remains of an Aqueduct, of which in some places there are entire Arches still standing. Among the Ruins of the old Town, I saw the Body of a *Roman* Statue of fine Alabaster, something bigger than the Life. Our Guide said his Father had seen it entire; but as it was an Idol of the *Gentiles*, they, like good Catholics, had broken it to pieces. He likewise told us that Urns of old Coins had been found there;

but not being Current in *Spain*, they had thrown them away. The place is called *Balonia*. It is over against *Tangier*, and frequently infested by the *Moors* from thence; on which account it is uninhabited. A small River, called *Alpariate*, runs by it: all which circumstances correspond with the ancient accounts of *Balo*. I have a Medal that was given me at *Tarifa*, with the following Letters upon it *B A I L O*, which probably belonged to this City, called by *Ptolomy* *Βάλων*. *Martianus Capella* Lib. VI. mentions it under the name of *Velonenfis Baticæ Civitas*. The Itinerary of *Antoninus* places *Balo* VI. M. P. West of *Mellaria*, which is about the distance of these Ruins from *Val de Vaca*.

About five Leagues farther is the Cape of *Trafalgar*; the sight of which immediately brought to my mind *Mela's* description of it. *Illud jam in Occidentem & Oceanum obliquo jugo excurrens, atque ei, quod Ampelustum esse dixeramus, adversum, &c.* Near the Capes Point are the Ruins often mentioned by the *Spanish* Authors, under the name of *Aguas de Mecca*. I was not there, but was assured at *Bejer de la Miel*, that there were still some Ruins on the Shore, and more in the Sea, that run all along under the Cape; particularly remains of a Mole, which must have made it a tolerable Harbour. These Ruins seem to be the remains of old *Bæsippo*. *Plin. L. III. Portus Bæsippo. Mela Bæsippo usque ad Junonis promontorium, oram freti occupat.*

The placing of Watch-Towers along the Coast of *Spain* to Alarm the Country, upon any Descent, seems to have been a practice of a long standing. *Livy* Lib XXII. C. 19. *Multas & locis altis positas turres Hispania habet, quibus & speculis & propugnaculis contra latrones utuntur: inde primo, conspectis hostium navibus, datum signum Asdrubali est, &c.*

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III. *A Letter of M. l' Abbé Conti, R. S. S. to the late M. Leibnitz, concerning the dispute about the Invention of the Method of Fluxions, or Differential Method ; with M. Leibnitz his Answer.*

J'Ai différé jusqu'à cette heure de répondre à votre Lettre, parce que j'ai voulu accompagner ma Réponse de celle que M. *Newton* (a) vient de faire à l'Apostille que vous y avez ajoutée. Je n'entrerais dans aucun détail à l'égard de la dispute que vous avez avec M. *Keill*, ou plutôt avec M. *Newton*. Je ne puis dire qu'historiquement ce que j'ai vu, & ce que j'ai lu, & ce qu'il me manque encore de voir & de lire, pour en juger comme il faut.

J'ai lu avec beaucoup d'attention, & sans la moindre prévention, le *Commercium Epistolicum*, & le petit Livre (b) qui en contient l'*Extrait*. J'ai vu à la Société Royale les Papiers Originaux des Lettres du *Commercium*; une petite (c) Lettre écrite de votre main à M. *Newton*; & l'ancien Manuscrit (d) que M. *Newton* envoya au Docteur *Barrow*, & que M. *Jones* a publié depuis peu.

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(a) In his Letter dated Feb. 26. 1715-16 *jt. vet.* and Printed at the end of *Raphsen's History of Fluxions*.

(b) Printed in the *Philos. Transf.* N. 342. and in Tome VII. *du Journal Littéraire*.

(c) Dated 17 March, 1693. and Printed at the end of *Raphsen's History of Fluxions*.

(d) Entitled *Analys: per Series numeræ terminorum infinitarum*.

De tout cela j'en infere, que si on ôte à la dispute toutes les digressions étrangères, il ne s'agit que de chercher si *M. Newton* avoit le Calcul des Fluxions ou infinitésimal, avant vous, ou si vous l'avez eu avant lui. Vous l'avez publié le premier, il est vrai; mais vous avez avoué aussi que *M. Newton* en avoit laissé entrevoir beaucoup dans les Letters qu'il a écrites à *Mr. Oldenbourg* & aux autres. On prouve cela fort à long dans le *Commercium*, & dans son *Extrait*. Quelles son vos Réponses? Voila ce qui manque encore au Public, pour juger exactement de l'affaire.

Vos amis attendent votre réponse avec beaucoup d'impatience, & il leur semble que vous ne sauriez vous dispenser de répondre. si non à *M. Keill*, du moins à *M. Newton* lui même, qui vous fait un deffi en termes exprès, comme vous verrez dans sa Lettre.

Je voudrois vous voir en bonne intelligence. Le public ne profite guere des disputes, & il perd sans ressource, pour bien de siècles, toutes les lumieres que ces mêmes disputes lui dérobent.

Sa Majesté a voulu que je l'informasse de tout ce qui s'est passé entre *M. Newton* & vous. Je l'ai fait de mon mieux, & je voudrois que ce fut avec succès pour l'un & pour l'autre.

Votre Probleme a été resolu fort aisément en peu de tems. Plusieurs Geometres à *Londres* & à *Oxford* en ont donné la Solution. Elle est générale, car elle s'étend à toutes sortes de Courbes, soit Geometriques, soit Méchaniques. Le Probleme est un peu équivoquement proposé: mais je croi que *M. de Moivre* ne se trompe pas, en disant, qu'il faudroit fixer l'idée d'une suite de Courbes. Par exemple supposer qu'elles ayent la même Soûrteangeante pour la même Abscisse; ce qui conviendra non seulement aux Sections Coniques, mais à une infinité d'autres tant Geometriques que

Mechaniques. On pourroit encore faire d'autres suppositions pour fixer cette idée.

Je vous parlerai une autre fois de la Philosophie de M. *Newton*. Il faut convenir auparavant de la Methode de Philosopher, & distinguer avec beaucoup de soin la Philosophie de M. *Newton*, des conséquences que plusieurs en tirent fort mal à propos. On attribué à ce grand homme bien de choses qu'il n'admet pas ; comme il l'a fait voir à ces Messieurs Francois qui vinrent à Londres, à l'occasion de la grand Eclipse.

Je suis avec tout le respect possible

A Londres le  
de Mars 1716.

Monsieur, vôtre &c.

N. B. *Mr. l'Abbé Conti spent some Hours also in looking over the old Letters and Letter Books kept in the Archives of the Royal Society, to see if he could find any thing which made either for Mr. Leibnitz, or against Mr. Newton, and had been omitted in the Commmercium Epistolicum Collinii & aliorum : but could find nothing of that kind.*

*A Letter of M. Leibnitz to M. L' Abbe Conti,  
in Answer to the former.*

Monsieur,

Hanover ce 14. d'Avril, 1716.

Pour ne vous faire attendre, je vous dirai par avance que j'ai répondu d'abord à l'honneur de votre Lettre, & en même tems à celle que Mr. *Newton* vous a écrite ; & j'ai envoyé le tout à Mr. *Remond* à Paris, qui ne manquera pas de vous le faire tenir. Je me suis servi de cette voie, pour avoir des temoins neutres & intelligens de notre Dispute : & M. *Remond* en fera encore part à d'autres. Je lui ai envoyé en même  
tems

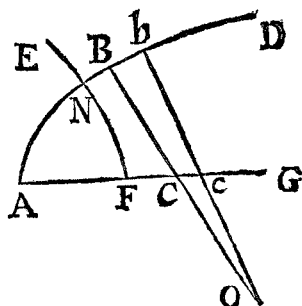
rems une copie de votre Lettre & celle de Mr. *Newton*. Après cela vous pourrez juger, si la mauvaise chicane de quelques uns de vos nouveaux Amis m'embarrasse beaucoup.

Quant au Probleme dont quelques-uns parmi eux ont voulu refoudre des cas particuliers, pour en fixer, disent-ils, les idées; il y a de l'apparence qu'ils se feront jeter sur des cas faciles: car il y en a dans les Courbes Transcendantes, aussi-bien que dans les ordinaires; mais il s'agit d'une solution generale. Ce Probleme n'est point nouveau. M. *Jean Bernouilli* l'a déjà proposé dans le mois de *May* des *Actes de Leipzig* 1697, p. 211. Et comme M. *Fatio* méprisoit ce que nous avions fait; on en repeta la proposition pour lui & pour ses semblables, dans les *Actes de May* 1700, p. 204. Il peut servir encore aujourd'hui à faire connoître à quelques-uns, s'ils sont allez aussi avant que nous en Methodes: & en attendant qu'ils trouvent le moyen de parvenir à la solution générale, ils pourront essayer ce qu'ils peuvent, en fixant les idées sur un cas particulier, qu'on leur propose dans le papier cy-joint. Sa solution vient encore du même M. *Bernoulli*. Ainsi vous aurez la bonté de ne pas vous rendre trop tôt aux insinuations de ceux qui nous sont contraires; comme lorsqu'ils vous font a croire que notre Probleme leur étoit aisé. Je suis avec zele, Monsieur Votre &c.

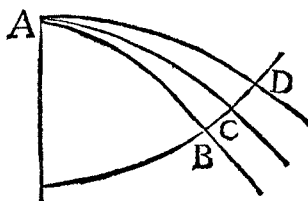
*Problema continens casum specialem Problematis generalis de invenienda Serie Curvarum, quarum qualibet sit ad aliam Seriem Curvarum perpendicularis.*

*Super*

Super recta AG tanquam axe, ex puncto A constructis Curvis quotcunque qualis est ABD, ejus naturæ ut radius osculi ex singulis singularum Curvarum punctis B eductus BO secetur ab axe AG in C in Data semper constanti ratione: ut nempe sit BO ad BC ut M ad N. Construende jam sunt Trajectoria qualis est ENF, priores Curvas ABD secantes ad angulos rectos.



Thus far this Letter. Mr. Leibnitz first proposed the general Probleme to M. l'Abbé Conti in these words; *Trouver une ligne BCD, qui coupe à angles droits toutes les courbes d'une suite déterminée d'une même genre; par exemple, toutes les Hyperboles AB, AC, AD, qui ont le même sommet & le même centre; & cela par une voye generale.* And in the *Acta Eruditorum* for October, 1698. p. 470, 471. he calls the Curves in this determinate Series, *Curvas ordinatim datas, & positione datas, & positione ordinatim datas.* And by all this, the Series of Curves to be cut is given, and nothing more is to be found, than the other Series which is to cut it at right Angles. But Mr. Leibnitz being told that his Probleme was solved, he changed it into a new one, of finding both the Series to be cut and the other Series which is to cut it. And the particu-



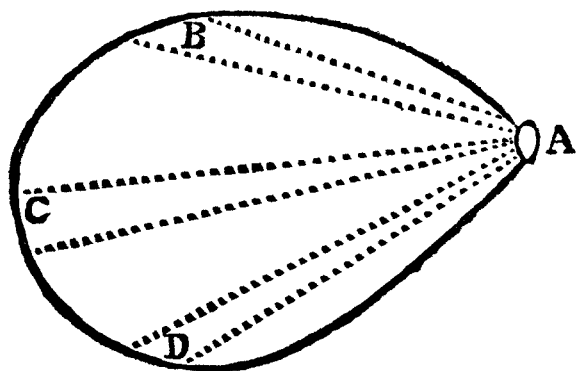
lar Probleme proposed in this Letter is a special Case, not of the general Probleme first proposed, as it ought to have been, but of this new double Probleme. And the first part of this double Probleme (*viz.* by any given property of a Series of Curves to find the Curves) is a Probleme harder than the former, and of which a general Solution is not yet given. Mr. *Leibnitz* in a Letter to Mr. *John Bernoulli*, dated 16 December, 1694. and published in the *Acta Eruditorum* for October 1698. p. 471, set down his Solution of the Probleme, when the given Series of Curves is defined by a finite Equation, expressing the relation between the Absciss and Ordinate. The same Solution holds when the Equation is a converging Series, or when the property of the Curve to be cut can be reduced to such an Equation, by the *Analysis per Series numero terminorum infinitas*. But Mr. *Leibnitz* was for solving the Probleme without converging Series.



IV. *Pars reliqua Dissertationis De Potentiâ Cordis.*  
*Authore Jacobo Jurin, M. D. & R. Societatis Soc.*

*Theorema II.*

**S***I ex Machinâ cavâ inæqualiter contractili, A B C D, aqua per Machinâ contractionem exprimatur, Motus aqua ex orificio A profilientis æquatur Summæ Factorum ex*



*Sectionibus quibuscvis transversis omnium aquæ filamentorum A B, A C, A D; singulis ductis in longitudines & velocitates respectivas.*

*Demonstratio.* Loco filamentorum aquæ, concipiatur Machina tubis minimis, inæqualiter amplis, A B, A C, A D, in orificium A desinentibus, tota constare.

Est aquæ Motus in quovis tubo æqualis sectioni cuivis ipsius tubi, ductæ in velocitatem aquæ per sectionem istam fluentis, & longitudinem tubi, per *Theor. 3.*

*De Motu Aquar. fluent.* Proinde Summa Motuum aquæ in omnibus tubis simul sumptis, sive Motus aquæ ex Machinæ orificio prorumpentis, æqualis est Summæ Factorum ex omnium tuborum sive filamentorum aquæ sectionibus, ductis in longitudines, & velocitates, respectivas. 2 E. D.

*Corol. 1.* Motus aquæ effluentis minor est Facto ex orificio A. velocitate aquæ exeuntis, & longitudine filamenti aquæ omnium longissimi. Est enim Factum ex orificio & velocitate aquæ effluentis, æquale Summæ Factorum ex sectionibus filamentorum singulis ductis in velocitates respectivas; & Summa horum factorum, ducta in longitudinem filamenti omnium longissimi, major est quam Summa eorundem ductorum cujusque in suam longitudinem.

2. Motus Aquæ æquatur Facto ex orificio A & velocitate aquæ exeuntis, ducto in longitudinem aliquam mediam inter longitudines filamentorum longissimorum & brevissimorum: vel æquatur Facto ex quantitate aquæ dato tempore effluentis, & longitudine mediâ prædictâ, applicato ad tempus illud datum.

3. Si Machinæ plures similes aquâ plenæ similiter contrahantur, sive æquabili velocitate mediâ, sive inæquabili, similiter tamen in omnibus Machinis auctâ, vel imminutâ; Motus, quo aqua ex Machinæ cujusque orificio prorumpit, rationem habet compositam ex ratione quadruplicatâ Diametri cujusvis homologæ ipsas Machinæ, & reciproci temporis ratione, quo peragitur Machinæ contractio: vel rationem compositam, ex ratione ponderis Machinæ, vel molis aquæ, sive Machinâ contentæ, sive ex eâdem expulsæ, ratione ejusdem ponderis, vel molis, subtriplicatâ, & ratione temporis reciproci.

## P R O B L E M A.

*Invenire Potentiam Cordis.*

Sit  $p$  = Pondus Ventriculi finiftri, five quantitas Sanguinis eidem ponderi æqualis.

$S$  = Superficies interna ejusdem.

$l$  = Longitudo media filamentorum Sanguinis ex eodem prodeuntium.

$s$  = Sectio Aortæ.

$q$  = Quantitas Sanguinis Ventriculo finiftro contenti.

$t$  = Tempus, quo Sanguis ex Corde expellere-  
tur, fublata Arteriarum & Sanguinis praece-  
dentis refiftentiâ.

$v$  = Velocitas variabilis, quâ Sanguis ex Corde  
profiliens per Aortam fluere, fublata refi-  
ftentiâ.

$x$  = Longitudo variabilis Aortæ à Sanguine ex  
Corde effluente percurfa.

$z$  = Tempus, quo longitudo  $x$  percurritur.

Inde velocitas media variabilis Sanguinis Ventriculo  
contigui, five media velocitas ipsius Ventriculi  $= \frac{sv}{s}$ .

Motus Ventriculi (per *Theor. 1. Cor. 2.*)  $= p \times \frac{sv}{s}$ .

Motus Sanguinis effluentis (per *Theor. 2. Cor. 2.*)  $= sv$   
 $\times l + x$ .

Horum Summa, five Potentia Ventriculi  $= sv \times$   
 $\frac{p}{s} + l + x$ . Est autem  $v = \frac{x}{t}$ . Unde per Methodum  
Newtonianam inverfam, elicitur Potentia Ventriculi  $=$   
 $\frac{sx}{t} \times \frac{p}{s} + \frac{x}{t} + l$ . Sed cum  $z = t$ , erit  $sx = q$ .

Hinc Potentia Ventriculi  $= \frac{q}{t} \times \frac{p}{s} + \frac{q}{ts} + l$ .

Simili

Simili ratione invenitur Potentia dextri Ventriculi

$$= \frac{q}{t} \times \frac{\pi}{\Sigma} + \frac{q}{2\sigma} + \lambda.$$

Literis autem Græcis eadem significantur in dextro Ventriculo, quæ Latinis in sinistro.

Hinc tota Cordis Potentia

$$= \frac{q}{t} \times \frac{p}{s} + \frac{\pi}{\Sigma} + \frac{q}{2s} + \frac{q}{2\sigma} + l + \lambda. \quad Q. \quad E. \quad I.$$

Si ponatur

$$p = 8 \text{ unc. Avoird} = 13.128 \text{ unc. cub.}$$

$$\pi = 4 \quad = 6.564$$

$$s = 10 \text{ unc. quadrat.}$$

$$\Sigma = 10$$

$$l = 2 \text{ unc.}$$

$$\lambda = 1 \frac{1}{2}.$$

$$q = 2 \text{ unc. Avoird.} = 3.282 \text{ unc. cub.}$$

$$s = 0.4185 \text{ unc. quadrat.} \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{Ex Keillianis Experi-}$$

$$\sigma = 0.583 \quad \text{mentis.}$$

$$t = 0.1''$$

Erit Potentia Ventriculorum æqualis motui ponderum subscriptorum, nempe, lib. unc.

Ventriculi sinistri \_\_\_\_\_ 9 . 1

Ventriculi dextri \_\_\_\_\_ 6 . 3

Cordis totius \_\_\_\_\_ 15 . 4

Quorum ponderum ea est velocitas, quâ percurratur longitudo uncialis singulis minutis secundis.

Cor. I. Quoties Pulsus fit celerior; aut minuitur resistentia, aut Potentia Cordis augetur, aut minor solito Sanguinis copia singulis contractionibus ex Corde expellitur.

2. Si Pulsus solito tardior fiat; necesse est, vel augeatur resistentia, vel Cordis Potentia minuatur, vel major Sanguinis moles ex Corde ejiciatur.

3. Aucta

3. Au<sup>ct</sup>a resistentiâ, necessario vel Pulsus retardabitur, vel augebitur Cordis Potentia, vel Sanguinis quantitas solito minor ex Corde exprimetur.

4. Imminutâ resistentiâ, vel Pulsus acceleratur, vel major Sanguinis copia quâque Systole ejicitur, vel Cordis vires minuuntur.

5. Au<sup>ct</sup>is Cordis viribus, necessario vel augebitur resistencia, vel Pulsus accelerabitur, vel plus Sanguinis ex Corde ejicietur.

6. Viribus Cordis imminutis, vel minuatur necesse est resistencia, vel Pulsus tardior fiat, vel minus Sanguinis ex Corde exprimatur.

7. Cum minor Sanguinis moles ex Corde projicitur; vel acceleratur Pulsus, vel Cordis vires minuuntur, vel augetur resistencia.

8. Cum plus Sanguinis ex Corde exprimitur; vel Pulsus tardior fiet, vel augebitur Cordis Potentia, vel resistencia minuetur.

*Schol. 1.* Ventrliculorum superficies internas, cum factu difficillimum videatur, ut accurate determinentur, aut etiam ratio habeatur imminutionis. quam inter contrahendum patiuntur, contenti fuimus præterpropter æstimare: cum sive easdem 12, sive 8 unciis quadratis singulas æquales statueris, perparva reperitur Potentiarum facta mutatio. Quod etiam observari poterit de longitudine mediâ filamentorum Sanguinis. Præterea differentias, quâ Arteriæ ambæ, earumque rami proximi à Corde progredientes, sectione augentur, ut æstimatu perdifficiles & pene insensiles, negligimus. Alioqui esset Cordis Potentia tantillo minor statuenda, quam quæ supra definita est.

2. Determinavit Vir Celeberrimus, *Jacobus Keillius*, velocitatem sanguinis, resistentiâ submotâ, ex Corde effluentis, eam circiter, quâ percurrantur pedes  $6\frac{1}{4}$  singulis minutis secundis. Ponit vero ille celeritatem Sanguinis

guinis per totam Systolem æquabilem, quam nos insigniter inæqualem fieri, & perpetim à Systoles initio retardari supra ostendimus. Hanc si cui definire libuerit, substituenda est, in quartâ Æquatione supra positâ, Potentia Ventriculi proxime inventa, & ipsi  $x$  valor quivis tribuendus, ut eliciatur  $v$ , sive velocitas eidem respondens. Ita, cum initio Systoles sit  $x = 0$ , sub finem vero  $x = \frac{7}{5}$ , determinatur inde ea Sanguinis velocitas initio Systoles, quâ pedes  $14\frac{1}{4}$ ; in fine autem quâ  $4\frac{1}{4}$ , minuti secundi spatio percurrantur. Pariter in dextro Ventriculo: velocitas Sanguinis initialis pedes circiter  $10\frac{1}{2}$ , ultima vero 3 pedes eodem temporis spatio conficiet.

Adhibuimus hæcenus eam Hypothesin, quâ Musculi Cordis Ventriculos constituentes Motum omnem, quo adiguntur in contractionem. Momento temporis concipiunt. Quod si ponamus Motum iis communicari non unico quidem Momento, sed tantillo tamen temporis spatio, quod cum totâ Systoles duratione comparatum rationem obtineat admodum exiguam; erit Cordis Potentia paululo major statuenda, quam quæ supra determinata est. Si vero statuatur iste Motus, procedente Systole, in ratione temporis augeri; erit totus Motus in fine Systoles acquisitus duplo major quam supra posuimus, ubi nulla resistentia Sanguini ex Corde profluenti objicitur: Ubi autem solita adest resistentia, erit idem quintuplo major; quod instituto calculo facile patebit. Pari ratione poterit calculus noster ad aliam quamlibet Hypothesin, quâ Ventriculorum Motus in duplicatâ vel superiori quâvis ratione temporis augeatur, accommodari. Potentia vero in fine acquisita suprapositâ elicietur longe major, nempe ex ratione duplicatâ Potentia tripla, ex triplicatâ quadrupla, ex quadruplicatâ quintupla, & sic in infinitum.

Nobis

Nobis autem videtur secunda Hypothesis, quâ Ventriculi parvo admodum temporis spatio Motum omnem concipiunt, cæteris longe verisimilior. Quum necesse sit, ut aliquid temporis impendatur ad Motum quemlibet generandum; neque videatur adeo tarde incrementum Ventriculorum Motus, ut non celerius augeatur, quam secundum temporis rationem. Motus enim Musculorum impetu solo Fluidorum quorumcumque, quæ ex Sanguine proveniunt, perfici nequit; quum Brachio alterutro Motum exercere possimus Motu Sanguinis per vasa Corporis universa profluentis longe majorem. Relinquitur ergo, ut Musculorum fibræ Ventriculos Cordis constituentium, rarefcentiâ quâdam liquorum in easdem influentium, in Motum impellantur. Hæc autem, quoties vim magnam concipit, plerumque subita est, & fere instantanea. Adde quod Ventriculorum Motus secundum hanc Hypothesin longe minor efficitur, quam in tertiâ. Non solet autem sapientissimus Artifex, Rerum Conditor, in operibus suis plus Virium adhibere, quam quantum sufficit ad finem propositum consequendum.

Cæterum sive admittatur ista Hypothesis, sive alia quæcunque ex supra dictis verior censeatur, poterunt omnia Corollaria nostra eodem jure ex Problemate deduci. Quæ utrum aliquid adjumenti afferant ad Morborum Historiam explicandam Medico sagaci considerandum permittimus. Facile autem ex Morbi cujusque Naturâ sciri poterit, utrum aucta sit vel imminuta resistantia. Augeri vero credibile est vel imminui Cordis vires auctis vel imminutis Musculorum reliquorum viribus; quamvis aliter statuissè video Virum Celeberrimum, *Laurentium Bellinum*.

*Theorema III.*

*Totus Motus resistentiæ, quæ Sanguini ex Corde erumpenti durante Systole objicitur, sive totus Motus, qui Sanguini præcedenti & Arteriarum tunicis communicatur, toti Cordis Potentia quamproxime equalis est.*

*Dem.* Peractâ Cordis Systole, quæ pars Aortæ & Arteriæ Pulmonalis Cordi proxima est, perstat plena Sanguine per totam Systolem Arteriarum. Nec enim patitur earum fabrica & nexus, quo Cordi conjunctæ sunt, ut tunicis in sese penitus collabentibus totæ occludantur, neque potest earum cavum Sanguine vacare. Alioqui enim, contrahentibus sese reliquis Arteriarum partibus, Sanguis iisdem contentus retro in vacuum impelleretur motu, & inutili & motui Sanguinis naturali contrario. Tum etiam Valvulæ Semilunares non tenderent versus Ventriculos, adeoque Sanguis ex Auriculis in Ventriculos expressus, etiam in Diastole Cordis, in Arterias protruderetur.

Hinc patet Sanguinem proxime ex Corde expulsum Systole peractâ immotum in Arteriis persistere, adeoque tum omnem Ventriculorum Motum excepiſſe, tum eundem totum partim Sanguini antecedenti, partim tunicis Arteriarum communicasse. Q. E. D.

*Theorema IV.*

*Motus, qui in Systole Cordis communicatur Sanguini præcedenti, est ad Motum tunicis Arteriarum communicatum, ut tempus Systoles Cordis ad tempus Diastoles quamproxime.*

*Dem.* Quum Sanguis per vasa Corporis universa, si partes Arteriarum Cordi propiores exceperis, æquali cursu deferatur; necesse est, ut tum Motus affricu Sanguinis ad valorum latera deperditus, tum Motus Sanguini redditus à Systole sive Cordis sive Arteriarum



rum, æqualibus temporibus æqualis sit. Qui autem Motus à Systole Arteriarum Sanguini communicatur, idem est præcise, qui prius à Cordis Systole Arteriarum tunicis fuerat impressus, cum Arteriæ eodem imperu quo distractæ fuerint etiam restituantur. Et Systole Arteriarum cum Cordis Diastole duratione convenit. Unde patet Propositum. *Q. E. D.*

*Cor.* Si ponamus cum Viro Doctissimo *Jacobo Keillio*, Systolen Cordis peragi tertiâ parte temporis inter Pulsus binos intercepti ; erit Motus Sanguini præcedenti communicatus totius Potentiæ Cordis pars tertia : Motus vero Arteriis communicatus prioris duplus, sive duæ partes tertiæ totius Cordis Potentiæ.

### *Theorema V.*

*In diversis Animalibus Potentia Cordis rationem obtinet compositam, ex ratione quadruplicatâ Diametri cujusvis hominologæ Animalis, & ratione inversâ temporis, quo Cor contrahitur : vel rationem compositam, ex ratione ponderis vel ipsius Cordis vel integrî Animalis, ratione ponderis ejusdem subtriplicatâ, & ratione temporis reciprocatâ.*

Facile demonstratur vel ex *Corol. 3. Theor. 1 & 2.* vel ex Potentiâ Cordis Problemate præcedente definitâ,

*Cor. 1.* Si ponatur Cordis Potentiam rationem obtinere ponderis vel ipsius Cordis, vel integrî Animalis, vel Sanguinis copię in toto Animali ; erit Animalis longitudo in ratione temporis, quo Cordis Systole perficitur, sive in ratione inversâ frequentię Pulsuum.

2. Si ratio longitudinis integrî Animalis major fuerit ratione inversâ frequentię Pulsuum, necesse est major sit ratio Potentiæ Cordis ratione ponderis ejusdem.

*Schol.* Quum constet Experimentis Puerorum Pulsus non esse tanto frequentiores Pulsibus Virorum, quanto Pueri Virorum longitudine superantur, concludendum

E f f f f f f 2

est,

est, vi secundi Corollarii, Potentiam Cordis Virilis majorem obtinere rationem ad Potentiam Cordis Pueri, quam est ratio ponderum. Et par est ratio in cæteris Musculis. Nam si Corporis robur rationem ponderis sequeretur, possent Pueri æqualia itinerum spatia eodem tempore cum Viris conficere.

Simili ratione ac Motum Sanguinis ex Ventriculis Cordis erumpentis ope secundi *Theorematis* determinavimus, poterit quoque Urinæ Motus ex Urethrâ profluentis determinari. Nempe si ponatur Urethræ & Veficæ longitudo 12 unciis æqualis, & binæ uncia Urinæ minuti secundi spatio emittantur, erit Motus Urinæ effluentis æqualis Motui ponderis libræ  $1 \frac{1}{2}$ , quod uncialem longitudinem singulis minutis secundis percurrat. Quoniam vero Urina non solis Veficæ Urinariæ viribus contractivis, sed etiam Diaphragmatis & Musculorum abdominalium ope in subsidium vocatâ, expellitur, nequit Veficæ Potentia ex Motu Urinæ profluentis æstimari.

Hæc tu, Vir Doctissime, æqui bonique consulas rogo: ipse autem ut diutissime valeas, utque existimationem tuam, & ipsam Artis Æsculapiæ dignitatem usque ut hætenus fecisti, insigniter tueri pergas, ac magis indies magisque extendere, idcirco ex animo voveo, quia publicam ad salutem pertinere arbitror.

Calendis *Januarii*,

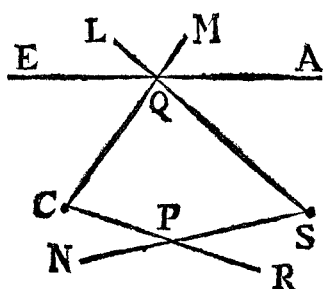
171 $\frac{1}{2}$ .

V. Nova

V. *Nova Methodus Universalis Curvas Omnes cujuscunque Ordinis Mechanicæ describendi sola datorum Angulorum & Rectarum Ope. Per Colin Maclaurin in Collegio Novo Abredonenfi Matheseos Professore.*

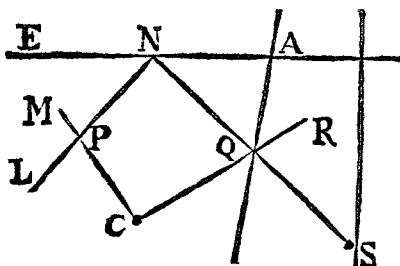
**I**Nter innumera sublimiaque Magni *Newtoni* inventa, quibus Geometria amplissime ditata in immensam excrevit luculentissimæ Cognitionis molem, Constructionem exhibuit Curvarum Mechanicam, post Enumerationem Linearum Tertii Ordinis, ad finem *Opticæ* editam, arduo summi Viri ingenio dignam; quæ simpliciore & simul adeo Universalem aliam exhibuit Nemo. Methodum vero suam ad Curvas Tertii Ordinis puncto duplici carentes, aut eas altiores Ordinis puncto multiplice destitutas, non extendit; earumque descriptionem Problematibus Geometriæ difficilioribus annumerandam pronuntiat. Atque hinc in spem venio Methodum sequentem, qua Curvæ Geometricæ cujuscunque Ordinis, licet puncto duplici aut multiplice quovis destitutæ, construuntur, non fore Geometris ingratam.

I. Lineæ primi Ordinis ipsæ sunt Rectæ; quæ in uno solo puncto sibi mutuo occurrere possunt. Lineæ secundi Ordinis sunt Sectiones Conicæ, quæ in pluribus punctis quam duobus à rectâ quavis secari non possunt. Fæ vero omnes secundum Lemma 21. Lib. I. *Princip.* D. *Newtoni* sic construi possunt; Circa data duo puncta  
C & S

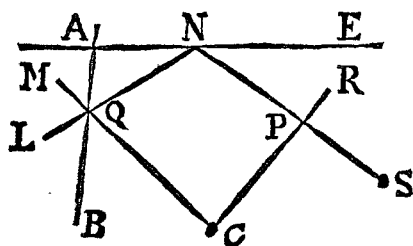


C & S moveantur Anguli dati MCR, LSN; ita ut Crurum CM SL concursus semper ducatur per rectam indefinitam positionem datam AE; tunc crurum aliorum CR & SN concursus in P describet Lineam secundi Ordinis seu Sectionem Conicam.

II. Moveatur ut prius Angulus MCR (v. Fig. 2.) circa datum punctum C; Angulus vero datus LNQ semper percurrat Angulari suo puncto N rectam datam



AE, ita ut crus NQ semper transeat per datum punctum S. 1. Si concursus crurum CR & SN, tum punctum Q ducatur per rectam infinitam AB, concursus crurum CM & NL describet Curvam lineam Tertii Ordinis punctum duplex habentem in C. 2. Reliquis manentibus, si crurum CM & NL concursus (vide Fig. 3.) ducatur per rectam indefinitam AB: concursus crurum CR & SN in P describet Curvam Tertii Ordinis



punctum duplex habentem in S.

Exem-

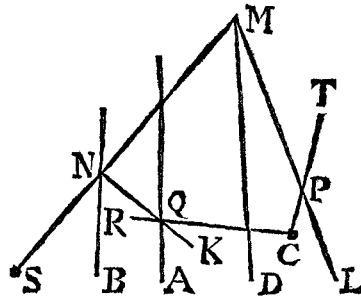




sus crurum CT, ML describet Lineam Quarti ordinis punctum triplex habentem in C.

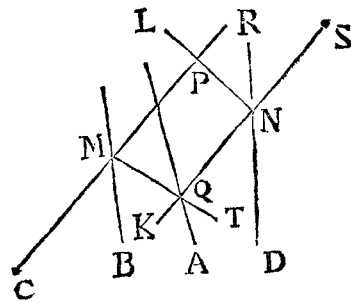
VI. Ostendi quo pacto Lineæ Quarti Ordinis describi possunt, quæ punctum triplex habent aut duo duplicia; Aliæ quæ unicum habent punctum duplex sic commode describuntur.

Sint tres rectæ ut prius positione datæ, AQ, BN, DM, dentur etiam Anguli SNK, SML, RCT; sint puncta N, M & S semper in eadem recta linea; Moveantur puncta N & M ut prius per rectas BN, DM;



Si concursus crurum CR, NK ducatur per rectam indefinitam AQ, tunc concursus crurum CT, ML describet Lineam Quarti Ordinis habentem punctum duplex unicum in C. Hæ vero duæ ultimæ Propositiones novas Methodus suppeditant lineas Tertii Ordinis describendi, tum quæ puncta duplicia habent, tum quæ iis destituuntur; Ex vero in brevi hoc Methodus Nostræ specimine sunt omittendæ.

VII. Maneant Anguli atque rectæ ut in Prop. III. Concursus vero nunc rectarum MT, NK ducatur per indefinitam rectam AQ; & Concursus crurum MR & NL describet Lineam Quinti Ordinis punctum quadruplex habentem in S. Habeo etiam alias Methodus curvas describendi



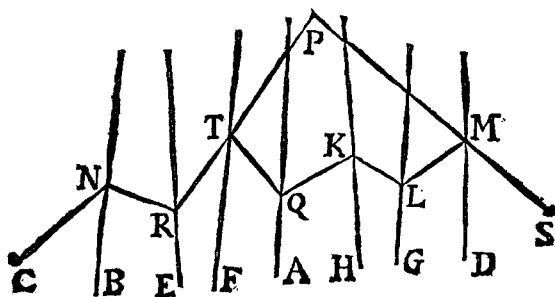
Quinti Ordinis, quæ punctum habent triplex, duplex, aut duo duplicia, vel nulla nisi puncta simplicia; sed

G g g g g g g

hæc

hæc sufficiant ad simplicitatem & universalitatem Methodus demonstrandam. Notandum vero in specialibus simplicioribus Angulorum & rectarum circumstantiis, Lineam aliquando migrare in curvam ordinis inferioris quam in *Prop.* explicatur; Imo singulæ Propositiones Methodus suppeditant particulares, curvas aliquas ordinis cujuscunque inferioris describendi.

VIII. *Propositio Generalis.* Sumantur ad libitum Rectæ in eodem plano ubicunque positæ, quarum sit numerus ( $n$ ) ut BN, ER, FT. Sumantur etiam ad libitum aliæ rectæ ut DM, GL, & HK &c. quarum sit numerus



( $m$ ). Sint Anguli CNR, NRT, RTQ &c. atque anguli SML, MLK, LKQ &c. invariati, dum puncta angularia N, R, T, M, L, K, percurrant rectas indefinitas BN, ER, FT, DM, GL, HK; Ducatur concursus crurum TQ & KQ per rectam indefinitam AQ; Invenire ordinem curvæ quam concursus cruris SM cum aliqua rectarum CN, NR, RT, TQ &c. ex. gr. cum RT, perpetuo tanget.

In Serie rectarum CN, NR, RT, TQ &c. denotet  $s$  numerum rectæ RT, cujus concursu cum SM Curva est describenda, à CN inclusive; qui in hoc casu est ternarius: erit Curva ordinis quem exprimit nume-



rus.  $s + m + s + n + 1$  : unde in casu quem figura designat, cum  $s = m = n = 3$  erit Curva ordinis 16<sup>ta</sup>.

In his descriptionibus Rectas solummodo atque Angulos dari postulavimus; sed facilius sæpe simpliciorum Curvarum ope complexiores describuntur; atque Propositiones his non minus Universales huc pertinentes investigavi: Eas vero cum harum demonstrationibus utpote prolixis impræsentiarum omitto; Easd postea publici juris facturus, si luce non videantur hæc Geometris indigna.

VI. *Extract of a Letter of the Reverend Mr. William Rice, Rector of Caerleon upon Usk, to Charles Williams Esq. giving an account of an ancient Roman Inscription lately found there. With some Conjectures thereon, by the Reverend Dr. John Harris, S. T. P. and R. S. S.*

Sir,

A Person last Week being at Plow in a Close near the Bank of the River *Usk*, which the Ancients called *Ifca*, (which glides by us about a quarter of a Mile off and in sight of this Town) came thwart a Stone, and finding Letters thereon, took it up whole; 'tis about a Yard in length, and about three Quarters broad I went to the place, and took a true Copy thereof, which I here make bold to send you. There was underneath it some seeming Oblong Square Sepulcher of Stones, rude in order. A little further in that Close, where that River wears out the Land, there was, some time before, a large Earthen Pot taken out of the Bank by the River-side, which had therein the Scull and Bones of some Person, by some thought to be a Child Murther'd; But I rather conjecture it a Roman Urn.

Caerleon, March 21.

1717.

Your humble Servant,  
William Rice.

D

D M

G. VALERIVS. G. F  
 GALERIA. VICTOR  
 LVGDVNI. SIG. LEG. II AVG  
 STIP. XVII. ANNOR XLV. CV  
 RA. AGINT. AMNIO. PER PITVO. B

*Sir,*

This ancient and fair Inscription confirms what others have found hereabouts; and what *Cambden* and other Historians shew us, viz. That the second *Roman Legion* called *Augusta*, brought into *Britain* by *Claudius Caesar* under the Conduct of *Vespasian*, was placed here at *Isca* or *Caer Legion*, by *Julius Frontinus*, in order to awe the *Silures*: And that General obtained several Victories over them and their Neighbours in several places hereabouts.

There seems to be nothing of Moment or of difficulty in this Inscription; but *Victor Lugduni*: Which as I think we have no ground from History to refer to *Lyons* in *France*, so I guess that Expression may be thus accounted for. The River *Lugg* is famous in the Neighbouring Parts; and as *Dynas* or *Dyn* hath been said to signifie a Town in the Ancient *British* Language; and that *Dun* doth also serve to express a Hill or *Down* as we still call it; (which I think is derived from the *British* also) probably *Lugduni* here may express some Town or Hi'l near the River *Lugg*; and since there is a Place called to this Day *Luckton*, on the side of the River *Lugg* in *Herefordshire*, perhaps that may bid fair to be the very place where *Valerius* obtained the Victory perpetuated by this Inscription.

# PHILOSOPHICAL TRANSACTIONS.

For the Months of *March, April and May 1719.*

## The C O N T E N T S.

- I. **D**E Maximis & Minimis *que in motibus Corporum Cælestium occurrunt.*
- II. *Apologia* D. Brook Taylor, J. P. D. & R. S. Soc. contra P. C. J. Bernoullium *Math. Prof. Basilæ.*
- III. *An Account of the Impression of the almost Entire Sceleton of a large Animal in a very hard Stone, lately presented the Royal Society, from Nottinghamshire, By Dr. William Stukely, M. D. and R. S. Soc.*
- IV. *A curious Description of the Strata observ'd in the Coal-Mines of Mendip in Somersetshire; being a Letter of John Strachey Esq; to Dr. Robert Welsted, M.D. and R. S. Soc. and communicated by him to the Society.*
- V. *Some Instances of the very great and speedy Vegetation of TURNIPS. Communicated by the Rev. Dr. J. Theoph. Desaguliers, R. S. S.*
- VI. *An Account of some Experiments tried with Mons. Villette's Burning Concave, in June 1718. By the Rev. Dr. J. Harris, and Dr. J. T. Desaguliers, Reg. Soc. SS.*
- VII. *An Account of the Extraordinary METEOR seen all over England, on the 19th of March 1718. With a Demonstration of the uncommon Height thereof. By Edm. Halley, LL.D. and Secretary to the Royal Society.*

I. De Maximis & Minimis quæ in motibus Corporum Cælestium occurrunt.

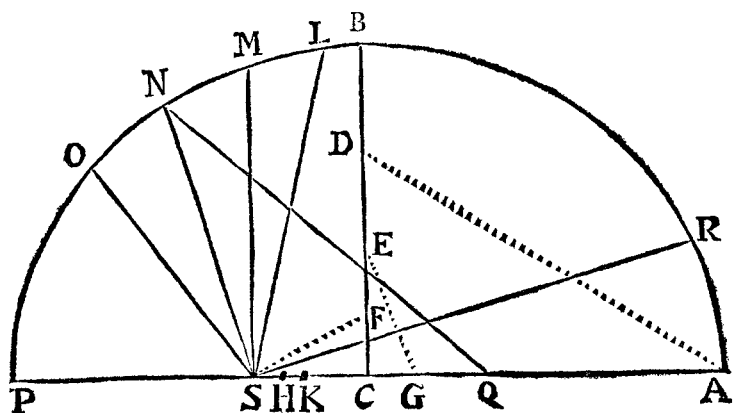
**A**NTE *Keplerum* Astronomi universi, per tot retro secula, Planetarum motum circularem non ausi sunt in dubium vocare, ex præconcep-  
tâ, ut videtur, in figura Circuli nescio qua perfectionis Ideâ. *Keplero* autem Inventori debetur ea qua nunc utimur Theoria, nempe quod Corpora cælestia Solem ambiunt in communi orbium Ellipticorum Foco situm, ea lege ut Areæ Temporibus proportionales radiis ad Solem ductis describantur. Sublimiorem vero postulat Geometriam, ad ostendendum quam ob causam hoc ita se habeat, quodque aliter esse non possit. Hoc in sempiternam celeberrimi D. *Newtoni* Præsidis nostri gloriam reservatum est.

Hujus vestigiis insistens, Corollaria quædam exhibuit eximius Mathematicus D. *Abr. de Moivre* R. S. S. in *Philos. Transact.* N° 352 edita; Theoremata scil. parata, quibus determinantur Velocitates sive Momenta Motûs tam veri quam apparentis circa Solem, sicut etiam accessûs vel recessûs à Sole, in dato quovis datorum Orbium puncto. Deinde ut Theoriam systematis Planetici penitus excoleret, ope eorundem Theorematum, dictorum Momentorum Momenta perscrutatus est, ostenditque quibus in orbium punctis fiant *Maximæ* harum Velocitatum mutationes, idque Solutionibus facilitate & concinnitate præstantibus.

Sit *ABP* Orbis Planetæ Ellipticus, *AP* Axis Transversus, *CB* Semiaxis conjugatus, *S* Sol, *Q* Focus alter Ellipseos. Per *S* ducatur *SM* ipsi *CB* parallela: & erit punctum *M* in quo *Maxima* cum velocitate cre-  
scit

scit vel decrefcit diftancia à Sole, &  $SM = AC - \frac{SC^2}{AC}$ .

Si vero capiatur  $SL$  media proportionalis inter Semiaxes  $AC$ ,  $CB$ , erit punctum  $L$  in quo *Maxime* fit æquatio Centri, ut vocant; five ubi motus angularis fit æqualis medio Motui: Quod fi Eccentricitas non major fit quam in plerisque Planetis,  $BL = BM$  quam proximè: Est vero  $SL = \sqrt{AC^2 - AC^2 SC}$ .



Si quæraturn punctum  $N$ , in quo fit *Maxima* mutatio Velocitatis motûs realis in Curvâ, Problema Solidum est. Est enim  $2NS = 4AC - 2NQ$  ad  $3NQ - AC$  ut  $AC^2 - CS^2 = CB^2$  ad  $NQ^2$ ; adeoque si ponatur  $AC = a$ ,  $CB = c$  &  $NQ = y$ , habebitur æquatio  $y^3 - 2ayy + \frac{1}{2}ccy - \frac{1}{2}acc = 0$ . Quâ resolutâ erit  $y$  five  $NQ$  distantia puncti quæfiti  $N$  ab altero Ellipseos foco. In Orbibus autem parum Eccentricis, quales sunt Planetarum, si fiat  $CD = SQ$ , & junctæ  $AD$  æqualis ponatur  $AK$ , erit reliqua pars Axis  $KP = NS$  distantie puncti  $N$  à Sole quamproxime. Si vero Orbis fuerit Parabolica erit  $SN$  ad  $SP$  ut 5 ad 4, angulusque  $NSP$  erit  $53^\circ. 8'$  fere, cujus Sinus est  $\frac{4}{5}$  Radii.

At Punctum  $O$ , in quo motûs apparentis five angularis acceleratio Planetæ descendens, vel retardatio  
\* ascendens.

ascendentis *Maxima* fit, hoc modo obtinebitur. In AC capiatur  $CG = \frac{1}{2}AC$ , ac fiat angulus CSF 30 gr. ductaque SF æqualis ponatur CE, ipsique GE sit GH æqualis. Dico, si distantia SO fiat æqualis ipsi PH, quod in puncto O proveniet *Maxima* mutatio motus angularis Planetæ in Orbe Elliptico ABOP gyrantis; eo scilicet in Orbis loco secundæ differentiæ æquationum centri Planetæ reperientur *Maxima*. Est autem  $SO = \frac{1}{2}AC - \sqrt{\frac{1}{30}AC^2 + \frac{1}{3}SQ^2}$ . Quod si Orbis Parabolica fuerit, ut in Cometis, fiet SO ad SP ut 8 ad 7, angulusque OSP fiet  $41^\circ. 24'\frac{1}{2}$ , sive cujus Sinus sit ad Radium ut  $\frac{1}{4}\sqrt{7}$  ad 1.

Denique *Minimâ* cum Velocitate mutatur directio Tangentis Orbitæ in puncto R, si fiat SR æqualis duabus tertiis Axis majoris AB. Quod si Eccentricitas SC minor fuerit quam  $\frac{1}{3}PC$ , *Minimum* hoc non locum habet, sed decrescit semper hæc Velocitas quacum revolvitur Tangens, usque in ipsum Aphelion; quemadmodum se res habet in omnium Planetarum motibus. Neque etiam in orbe Parabolico obtinet, ob Axem ejus in infinitum protensum.

Hæc omnia demonstrantur, juxta præcepta Doctrinæ de *Maximis & Minimis*, ex Theorematis prædictis in N° 352 exhibitis, quæ quidem hac occasione revivere Lectorem curiosum non pigebit.

## II. Apologia

II. *Apologia D. Brook Taylor, J V D. & R S. Soc.*  
*contra V. C. J. Bernoullium, Math. Prof. Basiliæ.*

**P**ACIS & concordiæ studioſo ſatius eſſet injurias vincere terendo, quàm odioſas contentiones bire ulciſcendo. Verum cum patientia noſtra pro ignaviâ habetur, ſilentium pro confeſſione criminis, & nuperam calumniam jam nova ſequitur contumelia, omnino reſpondendum eſt, ne nobis ipsis deeſſe videamur. In *Epiftola pro eminente Mathematico D. J. Bernoullio Actis Lipſienſibus An. 1716.* inſertâ, plagii reus ſiſtor ſequentibus verbis: “Hoc nihil novi eſt in quibſdam Angliſ, qui ſibi ſolis licere putant, *aliorum inventa tanquam ſua impunè uſurpare*; quando ipſi *Hominelque Deoſque invocant*, ubi vident, vel ſaltem videre arbitrantur Extraneos in ſuorum *Inventa manus inferre* Exempla ſunt quorundam, ut *Chey-næi Des Hayes, Taylori, aliorumque, qui paſſim inventis Bernoullii ſunt uſi alieniſque, vel nullâ prorsus factâ mentione Autoris, vel*.”—Palam eſt ab ipſo Bernoullio promanäſſe hanc accuſationem. Nam in *Actis Lipſienſibus An. 1718* <sup>1</sup> per filium ſuum fatetur ſe *res ipſas in illa epiftola contentas quoad maximam partem amico alicui perſcripſiſſe*. Invidiam equidem prædictæ calumniæ à ſe amovere ſollicitè ſtudet, atque transferre in vicarium illum ſuum, cum ipſe profiteretur, *ſe non approbare quæ in alios durius dicta cenſeri poſſunt* <sup>2</sup>. Sed admodum imperfecta eſt hæc purgatio. Nam calumniæ ſunt quæ durius dicta vocat. Ait ſe *dicta illa non approbare*: Sed improbaſſe neceſſe fuit. Teſtimonium

<sup>1</sup> Pag. 261.

<sup>2</sup> Pag. 262.

denique est pro se testantis : Autorem illum anonymum citasse oportebat, ut cum ipso agere liceret : Sed is adhuc latitat. Quam verè autem & ex animo *se durius dicta non approbare* videatur, constare quodammodo potest ex sequentibus, quæ de me ipse profert, proprio suo nomine, nullâ usus personâ : “ Taylorus Geometra  
 “ insignis & acurus, qui ad *profundiora nostra* feliciter  
 “ peneravit, teste ipsius libro de Methodo incrementorum, probè sentiens impeditam nimis Analyseos  
 “ fraternæ prolixitatem, eamque in compendium contrahere, ac simul generaliore nonnihil reddere volens,  
 “ tantam rei affudit obscuritatem ( quâ in aliis quoque  
 “ brevitate affectans impensè delectari videtur ) ut dubitem quenquam fore etiam inter perspicaciores, qui  
 “ ubique & hic imprimis mentem viri assequatur, imo  
 “ etiamsi aliunde rem cognitam habeat. Ut jam nihil  
 “ dicam de ipso calculo, pro more ejus, conciso quidem & contracto, satis tamen adhuc longo & intricato, si quis singula ejus capita minutim persequi  
 “ velit ; præterquam quòd cum Fratre meo ad tertias  
 “ quoque fluxiones excurrat ” <sup>3</sup>. Sit sanè liber ille meus nonnihil obscurus : Difficile est in re ferè nova, & ab usu communi aliquantulum remota, non esse obscurum. Sed maximè obscurum oportet esse librum, in quem illa omnia verè dicantur. Et si verè dicantur, tamen sine ullâ omnino causâ talia dixisse, ab ingenius moribus prorsus alienum est, & mera contumelia.

Sed audio Bernoullium de exordio conquerentem quonuper usus sum, in solutione problematis Leibnitiani in Transactionibus Philosophicis editâ. Stylum acriorem reprehendit quàm virum benè moratum deceat, item nimium contemptum Extraneorum. Quæ liberius effatus sum, hæc sunt : “ Si nondum viderint [ fautores

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3 Act. Leipf. An. 1718. M. Jan. p. 18.



Leibnitii] quomodo ex illa" [ ex anteriori nempe solutione generali] " æquationes sint deducendæ, id pro-  
 " fecto illorum imperitiæ tribuendum erit" 4. Hæc fateor paulò durius sonant; sed si ad causam attendas contumelia vacant. Fautores Leibnitii (non omnes intelligo, sed Bernoullium tantum, & Socios ejus anony-  
 mos nobis infensos,) universos Anglos indignè tracta-  
 runt. Solutionem illam generalem cum non intelligen-  
 rent, derisui habebant: In injuriosos & derisores me liberius explicui; contumelia non est. Sed ubi ille contemptus Extraneorum? Neminem ego nominatim citavi: De Fautoribus Leibnitii sum solum locutus. Sed absit ut omnes designatione illa omnino intelligerem quocunque modo causæ Leibnitii faventes; tanquam ipse causæ Neutonianæ essem tam pertinaciter addictus, ut alios omnes odio habeam. Sed controversia ista Neutonum inter & Leibnitium nihil ad me. Solos intellexi Fautores illos qui in Anglos essent insensi, qui me nominatim calumnia provocarunt; Bernoullium ite-  
 rum dico quem Principem agnovi causæ istius, soci-  
 osque ejus anonymos vel veros vel fictos. Hæc apertius dico, ne alii de nostra in alios contumelia im-  
 merito querantur. In immerentes injuria esset, in Ber-  
 noullium non est. Sed ad superiora illa redeo.

Plagii accusor, tanquam inventa Bernoullii, aliorum, u-  
 surpasserem ut mea. Exempla proferat, dabitur responsum.  
 Plura sanè tractavi cum aliis communia; sed inventis alienis sum minime usus ut meis. Propria ubique sum  
 usus Analyti, ( si Isoperimetrum excipias, de quo pos-  
 sica dicetur; ) ut nullo modo dici possit me alios frau-  
 dasse. At Autores nominasse oportebat, unde artem  
 hauseram. Tanta me quidem tenet reverentia illu-  
 strum nominum, Hugonii, Hospitalii, Varignonii, Leib

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4 Trans. Phil. N° 354.

nitii, aliorum, ut nesciam an ex hac parte non peccaverim, cum mihi ipsi deesse videar, cui tantos viros citasse temper fuisset ornamento. Nimia fortasse ignavia erat, quod de rebus cum essem maxime sollicitus, historias rerum penitus neglexerim. Sperabam tamen me in tantæ fraudis suspicionem incidere non potuisse, cum illustrissima tantorum virorum opera eam faciliè detegerent. Quæ cum Bernoullio communiter tractavi problemata, sunt de Funiculariâ, de Centro Oscillationis, & de Isoperimetris. In duobus primis sum propria omnino usus analysi; in Isoperimetro usus sum analysi Autoris Jacobi Bernoullii, Viri à rebus Mathematicis optimè meriti, cui debitos nunc persolvo honores. Solutio nostræ problematis de Centro Oscillationis, cum amicis meis communicata est usque ab initio Anni 1712. ut testes possim citare epistolas autographas Keillii nostri; Liber item noster erat penes Societatem Regiam, & cum omnibus fere nostris Mathematicis communicatus, usque a mense Aprilis Anni 1714. quod hic monitu necessarium duxi, ne & Solutionem illam sibi vindicet Bernoullius; cujus Solutiones <sup>5</sup> duæ extant eodem Anno editæ; quarum posterior cum nostra, quoad principia, tam mirè contēntit, ut jures ab eodem homine esse utraq; inventas. Materia de Isoperimetris excogitata primum est à Jacobo Bernoullio, sicut jam innuimus. Ejus extat solutio cum Analysis, in Actis Lipsiensibus Anni 1701. Extat Analysis fratris in Commentariis Regiæ Scientiarum Academiæ Anni 1706. Extat & solutio in Libro nostro. De eadem materia Commentarium nuper edidit Bernoullius in Actis Lipsiensibus Anni 1718. proximi <sup>6</sup>.

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<sup>5</sup> Altera in Act. Lipf. M. Jun. In Comm. Reg. Sc. Acad. M. Aug. altera.  
<sup>6</sup> P. 16. & seq. Has igitur aliasque ob rationes, actum agere minime videbor, &c. p. 18.

Ibi, ne actum agere videatur, non meis solummodo, verum etiam fraternis solutionibus malevolus detrahare aggreditur; fratri prolixitatem<sup>7</sup>, mihi obscuritatem<sup>8</sup> objiciens. De novis illis inceptis nihil non magnum<sup>9</sup> pollicetur; & *ope cujusdam principii, ab uniformitatis lege, quam nemo hucusque observavit, petiti*, rem totam pene sine calculo, nullo labore absolvet. Sed nescio quo fato fit, ut in hac materia de Isoperimetris, Bernoullius Deos omnes semper offendat iratos. Nam primo, pristina illa Analysis ejus à capite ad calcem quasi unum aliquod vitium maximum constituit: Secundo, quod tantum jactitat Principium, à lege uniformitatis, quam nemo hucusque observavit (sic enim strenuus affirmat) petitum, à me olim observatum est: Denique quam hic tanquam novam exhibet Analysin, tota mera fraterna est. Analysin enim constituunt Præcepta, juxta quæ deinde instituitur calculus; qui non Analy-

7 Nullos hic offendet Lector *scopulos*, quos objicit *operosa* Fratris analysis. atque differentiarum tertiarum *tricus ac spinas*, quibus *undique obsep-*  
*tam* ibi sentit viam, in nostra methodo nullas percipiet. — Nec fratris calculi prolixitatem, nec Taylori obscuritatem æque ingratam ac molestam sibi metuendam habeat, p. 18 — *quam Frater per operosissimam suam analy-*  
*si*: elicit, p. 23. — non tantum ea, quæ à fratre meo quondam propo-  
*sita magna pompa, nec minori conatu & labore soluta* fuere, ego ex sola lege uniformitatis solvi citra calculum analyticum, &c.

8 Vide Not. præced. — item quæ ex p. 18. jam sunt descripta.

9 — ætus confidam, *publicum ei gratiam habituram*, quod occasio mihi extiterit, talia nunc divulgandi, quæ fortè cum multis aliis in schedis meis perpetuò mansissent sepulta, quamvis *recondita Geometria fines non pa-*  
*rum prolatura*, p. 17. quod ibi ex incuria prætervissum reparabo hic *novo solu-*  
*endi modo*, qui singulari facilitate expedit problemata, non tantum omnia quæ de Isoperimetris proposuerat Frater, sed & innumera alia illis affinia, *ib.* — *ope cujusdam principii ab unifor-* . *mitatis lege, quam nemo hucusque ob-*  
*servavit, petiti*, ex sola figuræ inspectione, ac sine ullo pene calculo æqua-  
tiones pro curvis quaesitis sponte velut se offerentes ratiocinamur, &c. ut in Not. 7. actum agere minimè videbor si in hoc argumento per se difficili viam monstrem & rationem *brevem, planam, claram, & facilem* qua quic-  
que mediocri quoque ingenio præditus ad veritates illas abstrusiores (non  
fide aliorum, sed) propriis oculis spectandas pervenire possit, ita nempe,  
at, &c. ut in Not. 7.

sis.

sis est, sed instrumentum Analyseos. Præceptis semel positis, quivis faciliè calculum instituit, more quisque suo, hic prolixius, ille magis concinne, prout unicuique faverit Minerva. Negandum non est, Bernoullium calculum tandem concinnasse, & reddidisse elegantiorē; sed tamen in Analyſi fraterna fecit, non ſua: Nec dubitandum quin frater, adhuc ſi vixiſſet, rem reddidiſſet non minus illuſtrem. Analyſin diximus in præceptis contineri; præcepta verò ſunt omnia fraterna. Nam quod curvæ quæſitæ arcum minimum, tanquam ex tribus lineolis elementaribus compoſitum contemplatur, vel ipſo fatente <sup>10</sup> à fratre eſt: quod ex data longitudine arcuſi iſtius minimi quærit rationem differentiarum Ordinatarum in Lemmatis ſuis, à fratre eſt: quod rationem eandem denuo quærit, faciendo ut ſit areola naſcens, ex Functionibus ( ut vocat ) compoſita, vel maxima vel minima. à fratre eſt: quod denique ex duplici illa expreſſione ejuſdem iſtius rationis æquationem colligit qua curvæ quæſitæ natura definia-  
tur, à fratre eſt. Sed hæc Solutionem conſtituunt. Ergo Solutio mera fraterna eſt. Dixi me olim uſum eſſe Principio illo, quod tanta cum oſtentione ſibi arrogat Bernoullius: Ex eadem una pagina, in duo exem-

pla. In pagina 113. Libri mei hæc ſunt  $\overset{m}{\underset{R}{R}} = \overset{m}{\underset{R}{R}}$  .. Sed

“ eſt  $\overset{m}{\underset{R}{R}}$  novus valor ipſius  $\overset{m}{\underset{R}{R}}$ , unde eſt  $\overset{m}{\underset{R}{R}}$  quantitas

“ data ”. Luce clariuſ eſt me hoc loci ex obſervata

<sup>10</sup> Utar pro hoc, ut ipſe fecit in ſua Analyſi, contemplatione arcuſi minimi, &c. p. 18.

uniformitate inter formulas,  $\frac{m}{R}$ ,  $\frac{m}{R}$ , conclusiōe quod

fit  $\frac{m}{R}$  quantitas data. Idem feci in sequentibus. “Pone

“  $\frac{m''}{nR} = \frac{m'}{R}$ , hoc est  $\frac{m''n}{R} = \frac{m'n}{R}$ , &c”. ubi ut unifor-

mitas apparet inter formulas  $\frac{m''n}{R}$ ,  $\frac{m'n}{R}$ , æquationem

transformavi. Videtis, credo, quàm feliciter penetra-  
verim ad *profundiora* Bernoullii. An hæc obscura dicet?

Ad primam jam partem promissi pervenio, ut o-  
stendam pristinam illam Analysin Bernoullii esse omni-  
no corruptissimam. Primo per substitutionem satis ri-  
diculam, ex *profundioribus suis* nescio quibus petitam,  
æquationem  $F \times \Delta RO = \varphi \omega \times \Delta \rho \omega$  transformat in hanc  
 $FO \times \Delta^p F = \varphi \omega \times \Delta \pi \varphi$ ; quod in casu particulari (nem-  
pe quando functiones sunt ut quadrata ordinarum) huc  
redit, ut sint simul  $FO \times RO = \varphi \omega \times \rho \omega$  &  $FO \times$   
 $PF = \varphi \omega \times \pi \varphi$ ; unde constet  $PF : RO :: \pi \varphi : \rho \omega$ . Sed  
hoc impossibile est, quoniam est vel  $PF \supset RO \supset \rho \omega$   
 $\supset \pi \varphi$ , vel  $PF \supset RO \supset \rho \omega \supset \pi \varphi$ ; quorum neutrum cum  
analogia exposita conciliari potest. Nam si  $PF \supset RO$   
 $\supset \rho \omega \supset \pi \varphi$ , per Analogiam etiam erit  $\pi \varphi \supset \rho \omega$  (propter  
 $PF \supset RO$ ) contra hypothesin; vel si  $PF \supset RO \supset \rho \omega \supset \pi \varphi$ ,  
per Analogiam etiam erit  $\pi \varphi \supset \rho \omega$ , contra hypothesin.  
Secundo parum scienter fingit curvaturam in  $F$  esse ad  
curvaturam in  $\varphi$  sicut est  $\varphi O$  ad  $FO$ ; cum nihil in hac  
tota Analyfi sit quod privilegium illud vindicet puncto  
 $O$  potius, quam alio cuilibet puncto  $\omega$  in arcu mini-  
mo  $FO\omega\varphi$  ubivis sumpto. Nec sanè Curvedo tam ri-  
dicule

dicule vult affirmari. Tertia nimis imperitè facit  
 $mx = ddx$ ,  $nl = ddy$  &  $ml = \frac{d^2}{dx^2}$ , cum sint  $mx = \frac{1}{2} ddx$ ,  
 $nl = \frac{1}{2} ddy$ , &  $ml = \frac{d^2 ddy}{2 dx}$ . Denique quod omnium pes-  
 simum est, vitiosissimis hñce principiis perfectissimam  
 alligavit conclusionem. In problemate primo dico;  
 nam in secundo est talium parentum magis digna pro-  
 les. Errores Bernoulli ve eres & exoleros r. expo-  
 sisse putaris. Non ita est; ipse enim hac habet:  
 “ Omnia dudum supposita accuratè rursus excutiendo ad se-  
 “ veri examinis iudicium revocavi ”<sup>11</sup> Notandum au-  
 “ tem Solutionem primi problematis in tchediastmate  
 “ meo Commentariis 2<sup>o</sup> cap. p. 2. 5. inserto, rectissimè se  
 “ habere ”<sup>12</sup> Errores ergo suos jam denuo adopta-  
 vit. Unde fortasse nunc quaeret aliquis, Quo jure hic  
 primas sibi in sublimiori illa Analyti tam obstinata am-  
 bitione arroget? Ut nemo sit qui in illa aliquid profe-  
 cerit, quin continuo accusetur *ad profundiora Bernoulli*  
*penetross*<sup>13</sup>: Unde constet verum esse, quod quidam  
 nuper affirmavit, regulas extantes in libro de Analyti  
 infinitè parvarum à Bernoullio emanasse<sup>14</sup>? Quod lau-  
 des Excellentissimi Marchionis Hospitalii sint suo Præ-  
 ceptori tribuendæ? An hic sit idoneus qui alios do-  
 cuerit *regulas differentiandi differentias*<sup>15</sup>? Cum multis  
 aliis. quæ figillatim enumerare non est opus. Sed istis  
 respondeat qui volet: nos in hisce diutius non moramur.

<sup>11</sup> Pag. 16.      <sup>12</sup> Pag. 17.      <sup>13</sup> Pag. 18. vide etiam *Ep. pro Em.*  
*Math. & Scripta ipsius Bernoulli passim.*

<sup>14</sup> Concedit Dn. Marchionem de l'Hopital calculum istum intellexisse,  
 nec ignorat, illustrissimum hunc virum eundem à Cel. Bernoullio didicisse:  
 atque minime ipsam fugit, regulas in dicto libro [ *de Analyti infinitè parva-  
 rum* ] extantes à Cl. Bernoullio promanasse. *Act. Lips. An 1718. p. 464.*

<sup>15</sup> Dum inerea conjici potest, illum cum Dn. Newto o ab initio in  
 isto errore hæsisse, donec tandem liberati fuissent usu calculi differentialis, &  
*regulas differentiandi differentias à Cel. Bernoullio edocti essent. ib. p. 465.*

Res ipsas exposui. peroratione non utor ; harum enim tædet. Nec si quidquam regefferit Bernoullius, ulterius respondere necesse habebō. A contumeliis nos semel vindicare & jus & ratio postulat ; ulterius non expedit.

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III. *An Account of the Impression of the almost Entire Skeleton of a large Animal in a very hard Stone, lately presented the Royal Society, from Nottinghamshire. By Dr. William Stukely, M. D. and R. S. Soc.*

**H**AVING an Account from my Friend, *Robert Darwin, Esq;* of *Lincoln's-Inn*, a Person of Curiosity, of an human *Skeleton* ( as it was then thought ) impress'd in Stone found lately at the Rev. Mr. *John South's*, Rector of *Elston* near *Newark, Nottinghamshire*, I was desirous of a Description of it, for the Entertainment of the ROYAL SOCIETY, and have at length procured the Stone it self for their Repository, where such remarkable Appearances are best preserv'd, and deservedly valued. It cannot but be matter of Regret, that so considerable a Rarity, the like whereof has nor been observ'd before in this Island ( to my knowledge ) should be maim'd and imperfect, yet we may content our selves if enough be still visible to favour a Conjecture of what it has been. The Stone it self is a blue Clay Stone, the same as ( and undoubtedly came from ) the neighbouring Quarries of *Fulbeck*, or thereabouts, upon the Western Cliff of the long Tract of Hills extending quite through the adjacent County of *Lincoln*. It lay, time out of mind,

at the side of a Well near the aforesaid Mr. *South's* Parsonage-House, where it had serv'd for a Landing-place to those that drew Water; but upon removal, the Under-side exhibited this unusual Form, and was accordingly taken notice of by that worthy Gentleman, and laid up in his Garden for Curiosity-sake. Where the remaining part of the Stone, which contain'd the Upper part and Continuation of the *Skeleton*, or that which was the other side, and tally'd with it, may be, is now utterly unknown: but upon view, I am persuaded, it cannot be reckon'd Human, but seems to be a *Crocodile* or *Porpoise*. There are Sixteen *Vertebra* of the Back and Loyns very plain and distinct, with their Processes and intermediate Cartilages, Nine whole or partial Ribs of the Left-side, the *Os Sacrum*, *Ileum in situ*, and two Thigh-Bones displac'd a little, the Beginnings of the *Tibia* and *Fibula* of the Right-Leg; on one Corner there seem to be the *Vestigia* of a Foot with four of the five Toes, and a little way off an entire Toe, now left perfect in the Stone: there are no less than Eleven Joints of the Tail, and the Cartilages between them of a White Colour distinguishable from the rest. We should impose upon our Senses, to question, whether these be the real Reliques of an Animal; for the very Bones themselves are now to be seen as plainly, as if preserv'd in an *Egyptian* Mummy; a very little while ago, the Society had a Draught of a *Crocodile*, tho' a small one, found after the like manner inclos'd in Stone, from a Quarry in the Mountains of upper *Germany*. I suppose the same Reason accounts for both and all the rest of these kind of Fossils; and I please my self in an ocular Evidence, and so great a Confirmation of what I had the Honour to present to the *Royal Society*, in a late Discourse, where I hinted at a Solution of some obvious



vious and remarkable Phenomena, in the external Face of the Globe, consequent to its Formation, as set forth in the *Mosaic* Account; and of some Changes it suffer'd at the universal *Cataclysm*, and Proofs of that great *Catastrophe* of the animal and vegetable World in Plants, Shells, and Parts of living Creatures found in Rocks and Quarries.

Its remarkable, that all the Stone-Pits about the Country whence this came, abound with prodigious Quantities of Shells, and the like, and the greatest part of the Substance of the Stone is a Composition of them. There are many Accounts of them in the *Transactions*, and this Stone has many Shells of different kinds in it. Sir *Hans Sloan* has a Fish-Skeleton, amongst his immense Treasure of Curiosities, found near this Place, given by the Duke of *Rutland*. If we look upon a Map of the Country, and observe the *Lincolnshire Alps* which I spoke of before, how they run 50 Miles North and South, and on the West side are steep and rocky, we may see the Reason why these Quarries should be so stuf't with them; for it is just to conceive, that upon retiring of the Waters of the Deluge from the Superficies of this Country, into the Eastern Seas, these heavy Bodies met a full stop, and were intercepted by this Cliff, which has retain'd such vast Quantities of them ever since: whilst those which fell upon common Mold are mostly rotten, and now lost.

Sir *Isaac Newton's* Doctrine of the Attraction of the Particles of Matter, according to the Quantity of its Solidity, Proximity, and Surface, especially that it is infinitely greater in the point of Contact, upon which depends its Cohesion and all the Varieties of Physical Action, will easily direct us to a Notion of Petrification. We learn how a proper Degree of Heat or Cold,

Moisture, Motion, Rest and Time, promote this Principle, from the common Experiments of ChrySTALLIZATION and Freezing even before the Fire, and in many Chymical Mixtures. Whence we cannot be ignorant of Stone growing in the Quarries gradually, not by any fancied Vegetation, tho' there is something like it in Corals, but generally by Apposition of Parts to Parts, as is notorious in the *Fluors* of subterraneous Grotts and Caverns. So that we have no reason to doubt but what was Clay, Sand, or Earth 3000 Years ago, may now be Stone or Marble, according to the Proportion of Concurrence of such mentioned Causes. This will persuade us that the now barren and rocky Plains of the Countries of *Syria*, *India*, and *Arabia*, are owing to Natural Causes, as well as an immediate Curse of God for the Disobedience of its ancient Possessors his peculiar People, because the same is observable of the famous Countries of *Greece* and *Africa*, warm Regions so renowned for Fertility in antient Authors. Wherefore there may be some likelihood in the Opinion of those who think that in many Ages the whole Face of the Globe may become one great Rock. Dr. *Plott*, in his Natural History of *Oxfordshire*, gives an Account of a *Tumulus*, now a perfect Mount of Stone: and upon St. *Vincent's* Rock near *Bristol* are Fortifications now become solid Cliff. I remember, about six Years ago, Mr. *Ralph Widdrington*, Brother to the Earl of that Name, shew'd me many human Bones taken from whole Sceletons, with Brittish Beads, Chains, Iron Rings, Brass Bits of Bridles, and the like, which were dug up in a Quarry, near the Seat of the Family, at *Blankney*, *Lincolnshire*; which very probably was plain Mold, when these old Corpses of the *Britons* were interr'd; and since then I saw many human Bones and Armour, with *Roman* Coins, *Fibula*, &c. found in  
a Stone-

a Stone-pit in the Park at *Hurston*, *Norfolk*; belonging to Sir *Nicolas L'Estrange*, in whose Custody they now are, which were conjectured to have been buried in Earth after a Battle. From whence we may judge it a vulgar Mistake, when in the Ruins of old Castles and Walls, we admire the Tenacity of the Mortar, and are apt to praise our Ancestors, for an Art which we suppose now lost; when doubtless the Strength of the Cement is owing to the Length of Time: and in future Ages our Modern Buildings may obtain the same Judgment.

From all which Instances, I only desire to infer the antient state of these Cliffs, where this Sceleton was, and Shells are daily found, intimately mixt in the Substance of the Stone, to have been formerly of a softer Consistence, capable of admitting them into its Bowels, and to have immur'd them as part of it self; and that Earth which is now manageable by the Plough, may possibly in time assume the same Density, at least very little below the Surface; for in this very Cliff the upper *Strata* are yet Clay, growing harder as deeper. What Creature this has been, for want of a Natural History of Sceletons, well worthy the Endeavours of this Society, we cannot positively determine; but generally find the like to be amphibious or marine Animals. Why such rather than many others, should chance to be thus entomb'd, may be thought, because they were able much longer than Terrestrial Animals to live in that World of Waters, even till they began to abate and fall away into their destin'd Receptacles; so that while the Bodies of the rest soon perishing, were corrupted, and their Bones separated and dispers'd much earlier; this Sceleton, with others of its like, fell entire into the Fissures of this Bed of Clay, which has since turn'd into Stone, and made this noble Monument and  
pregnant

pregnant Token of that general Inundation, durable as the vain glorious *Egyptian* Monarchs Pyramids at *Memphis*; to be perpetuated in the lasting Records of this Society. See the Figure of this Impression, in Tab. I.

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IV. *A curious Description of the Strata observ'd in the Coal-Mines of Mendip in Somersetshire; being a Letter of John Strachey Esq; to Dr. Robert Welsted, M. D. and R. S. Soc. and by him communicated to the Society.*

**I** Now send you the Observations which I sometime since promised you, relating to the different *Strata of Earths and Minerals* found principally in the Coal-Mines in my Neighbourhood. For the better Illustration whereof, I have inclosed a Draught, which you must suppose the Section of a Coal-Country, and to take in about Four Mile from the North-West to South-East, and may be applied to the Veins of Coal as they lye at *Faringdon-Courny*, and likewise at *Bishop-Sutton*, which last Place is near *St. wy*, but in the Parish of *Chew Magna* in this County of *Somerset*. For Discovery of Coal, they first search for the *Crop*, which is really Coal, tho' very friable and weak, and sometimes appears to the Day, as they term it; or else for the *Cliff*, which is dark or blackish Rock, and always keeps its regular Course as the Coal does, lying obliquely over it. For all Coal lies shelving like the Tyle of a House, not perpendicular nor horizontal, unless it be broken by a *Ridge*, which is a parting of Clay, Stone, or Rubble; as if the Veins by some violent Shock were disjointed and broken, so as to let  
in

in Rubble, &c. between them. The Obliquity or *Pitch*, as they term it, in all the Works hereabout, is about 22 Inches in a Fathom; and when it riseth to the Land is called the *Crop*, but in the North *Basseting*. In the Works near *Stony*, and likewise at *Faringdon* it riseth to the North West, and pitcheth to the South East; but the farther they work to the South West, the *Pitch* enclines to the South; and *è contra*, when they work towards the North East. So likewise they observe. as they work to the South West, when they meet with a *Ridge* it causeth the Coal to *trap up*, that is, being cut off by the *Ridge*, they find it over their heads, when they are thro' the *Ridge*: but on the contrary, when they work thro' a ridge to the North East, they say it *traps down*, that is, they find it under their feet.

Coal is generally dug in Valleys or low Grounds. The Surface in these parts is mostly a red Soyl, which under the first or second Spitt degenerates into *Malm* or *Loom*, and often yields a Rock of Reddish *Firestone*, till you come to four, five, and many times to twelve or fourteen Fathom depth, when by degrees it changeth to a Gray, then to a Dark or Blackish Rock, which they call the *Coal Clives*. These always lye shelving and regular as the Coal doth. But in these parts they never meet with *Firestone* over the Coal, as at *Newcastle* and in *Staffordshire*. These *Clives* vary much in Hardness, in some places being little harder than *Malm* or *Loom*, in others so hard as that they are forced to split them with Gunpowder: So likewise in Colour, the top inclining to red or grey, but the nearer to Coal the blacker they grow; and wheresoever they meet with them they are sure to find Coal under them. But to their disappointment 'tis not always worth the digging. The first or uppermost Vein at *Sutton*

is called the *Stinking Vein*. It is hard Coal fit for Mechanick uses, but of a sulphurous Smell. About five Fathom and half, seldom more than seven Fathom under this, lyes another Vein, which from certain Lumps of Stone mixt with it like a *Caput mortuum* not Inflamable, called *Cats-head*, they call the *Cathead Vein*. About the same Depth under this again lyes the *Three Coal Vein*, so called because it's divided into three different Coals; Between the first and second Coal is a Stone of a foot, in some places two feet thick; but the middle and third Coal seem placed loose on each other, without any separation of a different Matter. These three Veins before-mentioned are sometimes work'd in the same Pit: But the next Vein which I am going to mention is generally wrought in a separate Pit; for tho' it lyes the like depth under the other, the *Cliff* between them is hard and subject to Water; wherefore I have represented a Pit sunk thro' the three Upper Veins at A. and another sunk upon the *three Coal Veins* only at B. and so if they sink on any of the lower Veins they go more to the North West. See Fig. Tab. II.

Next under the *three Coal Veins* is the *Peaw Vein*, so denominated because the Coal is figured with Eyes resembling a Peacock's Tayl, gilt with Gold, which Bird in this Country Dialect is called a *Peaw*. The *Cliff* also over this Vein is variegated with *Cockle-shells* and *Fern Branches*, and this is always an Indication of this Vein, which, as I before hinted, is always searched for about 15 Fathom to the North West of the former.

Under this again between five and six Fathom lies the *Smith's Coal Vein*, about a yard thick; And near the same depth under that again the *Shelly Vein*: And under that a Vein of 10 Inches thick, which being little valued, has not been wrought to any purpose.

Some say there is also another under the last, but that

that has not been proved within Man's Memory. At *Faringdon* they have the same Veins, which, as I am informed, agree in all Parts with those of *Bishop-Sutton* before-mention'd. But as *Faringdon* lies four Miles South-East from *Bishop-Sutton*, so, in the regular Course, they would lye a Mile and  $\frac{1}{2}$  deeper than those at *Sutton*. But as in fact they are dug near the same Depth, it follows there must be a *Trap*, or several *Traps* down, which in all must amount to that Depth between the said Works:

Between *Faringdon* and *High-Littleton* the same Veins seem to retain their regular Course; but at *Littleton* their undermost and deepest Vein is the best Coal, which at *Faringdon* proves small.

On the other hand, in the Parish of *Stanton-Drem*, to the North-East of the Coal-Works at *Sutton* afore-said, about a Mile distant, and in the true Course with those at *Sutton*, the same Veins are found again. But here they wind a little, and their Course or Drift runs almost North, and they dip to the East; which Winding is attributed to *Ridges*, which the Workmen have met with on both Sides, and have occasion'd them to discontinue the Work that way. At *Stanton* they have little of the Red Earth or *Malm* on the Surface, but come immediately to an *Iron-Gritt* or *grey Tile-Stone*, which is a Fore-runner of the *Coal-Clives*; in all other Matters they agree with the Works near *Stow*.

In the same Parish of *Stanton-Drem*, a little to the Eastward, they have another Coal-work, but the Veins are in all respects different from the former. Their Drift or Course is to the Eleven a Clock Sun, as they term it, they *Pitch* to the Five a Clock Morning, and rise to land; consequently to the Five a-Clock Evening-Sun. They have several Veins, but as yet only three are thought worth working. The uppermost about three

L111111

Feet

Feet thick small *Lime-Coal*. The next is about three Fathom under it, about two Feet and an half thick, fit for culinary Uses: the undermost is about the like Depth under the former, only 10 Inches thick, but good hard Coal.

At *Clutton*, about two Mile from these latter, in the same Drift, *viz.* almost to the South East and by South, these last Veins appear again. The Surface here is red, and so continues to ten, and sometimes to fourteen Fathom, and in other respects agree with the last-mention'd Works at *Stanton-Drex*.

At *Burnet*, *Queen-Charlton*, and *Bristleton*, they have Four Veins which Pitch to the North nearly, and consequently the Drift lies almost East and West. The Surface is red land generally to the Depth of four or five Fathom. The uppermost is from three to six Feet thick at *Bristleton*, but less at *Charlton* and *Burnet*. The next, call'd *Pot-Vein*, is six Fathom under the former, eighteen Inches thick, all hard Coal. *Thirdly*, The *Trench-Vein*, 7 Fathom under the other, which is from two Feet and half to three Feet thick, all solid Coal. *Fourthly*, *Rock-Vein*, always distinguish'd by a Rock of Paving-Stone, call'd *Penant*, lying over it, which Rock is sometime twenty Feet thick, or more, and therefore this Vein is never wrought in the same Pit with the former Vein, but about 200 Yards more to the South, or to Land, as they term it. It's computed seven Fathom under the former.

This is all I can say in relation to the different Veins of Coal and Earth in the Coal-works in these Parts; wherein all agree in the Oblique Situation of the Veins; and every Vein hath its *Cliff* or *Clivs* lying over it, in the same oblique manner. All of them Pitch or Rise about Twenty two Inches in a Fathom, and almost all have the same *Strata* of Earth, Malm,  
and

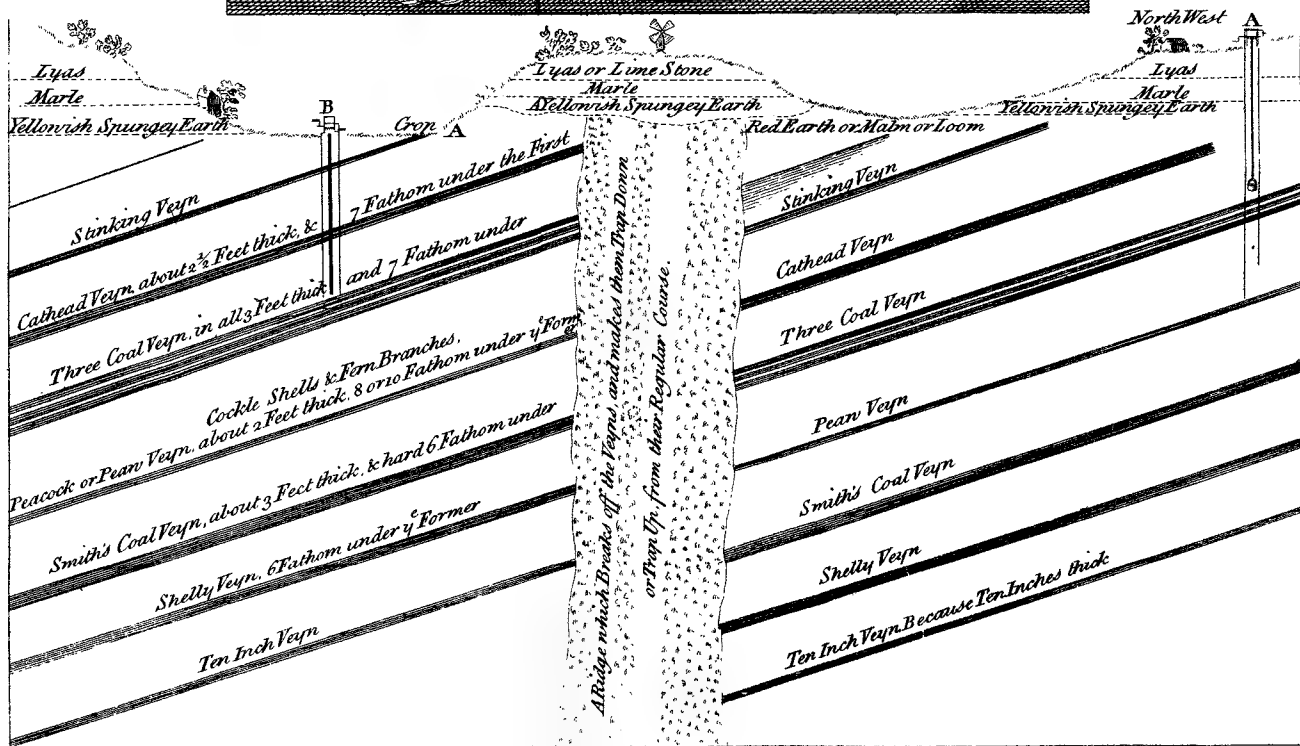
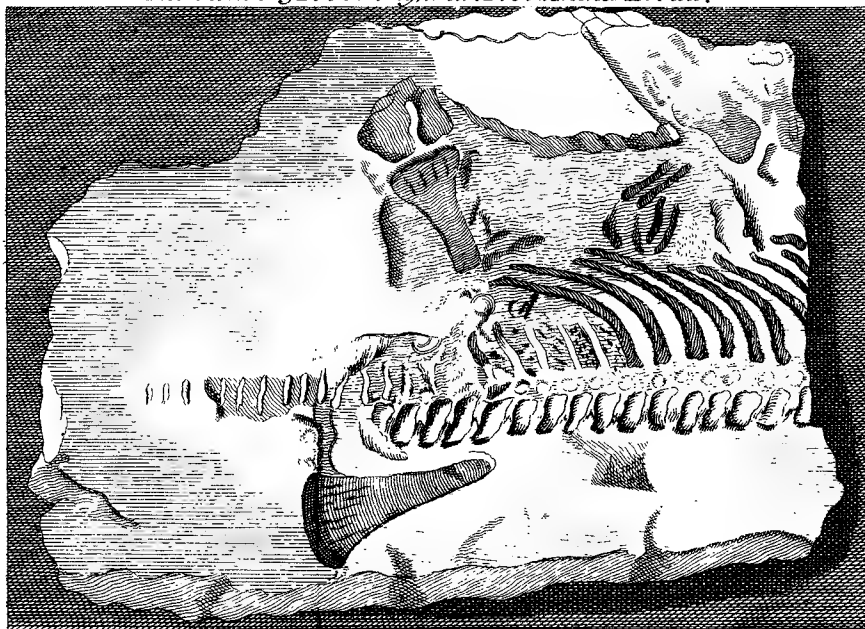


and Rock over them, but differ in respect to their Course or Drift, as also in Thickness, Goodness, and Use.

Now as Coal is here generally dug in Valleys, so the Hills, which interfere between the several Works before mentioned, seem also to observe a regular Course in the *Strata* of Stone and Earth found in their Bowels: For in these Hills (I mean those only that are dispers'd between the Coal-Works above mention'd) we find on the Summits a stony Arable mixt with a spongy yellowish Earth and Clay; under which are Quarries of *Iyas*, in several Beds, to about eight or ten Feet deep, and six Feet under that thro' yellowish *Loom*, you have a blue Clay enclinable to *Marle*, which is about a Yard thick: Under this is another Yard of whitish *Loom*, and then a deep blue Marle soft, fat, and soapy, six Feet thick; only at about two Feet thick, it is parted by a *Marchasite* about six Inches thick. But as this swells beyond the Bounds of a Letter, I must defer the farther Description of these and some *Lead-Mines* to another Opportunity; only 'tis to be noted, that these Beds of *Stone* and *Marle*, different from *Coal*, lie all Horizontal.

*Your humble Servant,*

John Strachey.



V. *Some Instances of the very great and speedy Vegetation of TURNIPS. Communicated by the Rev. Dr. J. Theoph. Desaguliers, R. S. S.*

**A**T Sutton Coldfield in Warwickshire, a peaty Ground near a Pool ( of which it was formerly a part ) was sown with *Turnip-Seed* on the 2d Day of July 1702. In less than Three Days Time the Turnips were seen above Ground. At Three Weeks end the Roots were in Bigness equal to Walnuts. Within less than Five Weeks after the Sowing, the Gardener drew great Quantities of Turnips to sell, they then being as big as large Apples. At the end of Six Weeks, *viz.* on the 12th Day of *August*, a large Turnip was plucked up ( though probably not so big as several others then growing upon the same Ground ) which, together with its Top and long descending part of the Root, weighed above Two Pounds and Fourteen Ounces. At the same time also was weighed an Ounce of the same sort of Turnip-Seed, that the Gardener had sown his Ground with; and afterwards a Thousand of the Grains were counted singly out of the Ounce so weighed; and the rest of the Ounce was divided into Heaps, as near as could be guessed, equal to the 1000 Seeds first severed and laid together: And it was found that the whole Ounce contain'd above 14600 single Grains; which Number multiplied by 46 (*viz.* the Number of Ounces that the Turnip weighed ) produceth 671,600, *viz.* the Number of single Grains of Seed required to equal the Weight of the Turnip. From whence may be gathered, that ( upon supposition, that the Increase of the Turnip was all along uniform and equal, from the  
Time

Time it was sown till it was pluck'd up ) the Grain of Seed which it sprung from, weighing when it was sown but  $\frac{1}{14600}$  of an Ounce, was increased in Weight according to the following Proportions, viz,

In Six Weeks time	—	671,600	} times its own Weight.
Every { Week	—	111,933 $\frac{1}{3}$	
{ Day	—	15,990 $\frac{1}{2}$	
{ Hour	—	666 $\frac{1}{4}$	
{ Minute of } an Hour }	—	11	

Some time after, another Ounce of the same sort of Seed was exactly weighed, and the Grains were found to be in Number 14673.

Another Turnip of the same Crop was plucked up on the 21<sup>st</sup> Day of *October*; and being put into a Scale, was found to weigh above Ten Pounds and an half; which unusual and truly wonderful Bulk it acquired (it being supposed, as above, that the Growth was all along alike) by increasing the Weight of the Seed it was raised from, 15 times in every Minute of an Hour from the Sowing to the Drawing of it.

The Gardener neglected to thin his Turnips in due Time, else probably their Growth had been more considerable.

At another Time, in two other sorts of Turnip-Seed, it was found by counting, that an Ounce of one sort contained 14702 Grains; and an Ounce of the other sort no fewer than 14905 Grains.

It's credibly reported, that of late Years, Turnips have been pretty frequently found growing in several Counties of this Kingdom, that have weighed above twice as much; one of which was seen at *Birmingham* about the Year 1710.

VI. *An Account of some Experiments tried with Monsr. Villette's Burning Concave, in June 1718. By the Rev. Dr. J. Harris and Dr. J. T. Desaguliers, Reg. Soc. SS.*

**T**HIS Miroir is a Concave 47 Inches wide, and ground to a Sphere of 76 Inches *Radius*; so that its *Focus* is about 38 Inches distant from the *Vertex* of the Glafs. The Metal of which it is made is a Mixture of Copper, Tin and Tin-Glafs, whose Reflexion has something of a yellow Cast. The Concave-Surface has scarce any Flaws, and those very small; but the Convex side, which is also polish'd, has some Holes in it.

Having held several Bodies in the *Focus* of this Miroir, we observ'd what happen'd to them whilst expos'd to this great Heat; and with an half second Pendulum took notice of the Time in which any material Change happen'd to them.

The Experiments were as follow, and made from Nine till Twelve in the Morning.

- N<sup>o</sup> 1. A red piece of a *Roman Patera*, which began to melt in 3 Seconds, was ready to drop in 100.  
 2. Another black Piece melted at 4, and was ready to drop at 64 Seconds.  
 3. Chalk taken out of an *Echinus Spatagus* fill'd with Chalk only, fled away in 23 Seconds.  
 4. A Fossile-Shell calcin'd in 7 Seconds, and did no more in 64.  
 5. A piece of *Pompey's Pillar* at *Alexandria*, was vitrified in the Black Part in 50 Seconds, and in the White part in 54.      6. Cop-

6. Copper-Oar, that had no Metal in it visible, vitrified in 8 Seconds.

7. Slag, or Cinder of the ancient Iron-work said to have been wrought by the *Saxons*, ready to run in 29 Seconds and an half.

*Here the Glass growing hot, burn'd with much less Force.*

8. Iron-Oar fled at first, but melted in 24 Seconds.

9. Talk began to calcine at 40 Seconds, and held in the *Focus* 64.

10. *Calculus humanus* in 2 Seconds was calcin'd, and only dropp'd off in 60.

11. An anonymous Fish's Tooth melted in 32 Seconds and an half.

12. The *Asbestos* seem'd condens'd a little in 28 Seconds; but it was now something cloudy: *Monf. Villette* says that the Glass usually calcines it.

13. A Golden Marchasite broke to pieces, and began to melt in about 30 Seconds.

14. A Silver Sixpence melted in 7 Seconds and an half.

15. A King *William's* Copper Halfpeny melted in 20 Seconds, and ran with an Hole in it in 31.

16. A King *George's* Halfpenny melted in 16 Seconds, and ran in 34.

17. Tin melted in 3 Seconds.

18. Cast Iron in 16 Seconds.

19. Slate melted in 3 Seconds, had an Hole in 6.

20. Thin Tile melted in 4 Seconds, had a Hole and was vitrifi'd thro' in 80.

21. Bone calcin'd in 4 Seconds, and vitrifi'd in 33. An Emerald was melted into a Substance like a Turquoise Stone.

A Diamond weighing 4 Grains lost  $\frac{2}{3}$  of its Weight. VII. *As*

VII. *An Account of the Extraordinary METEOR seen all over England, on the 19th of March 171<sup>8</sup>/<sub>9</sub>. With a Demonstration of the uncommon Height thereof.* By Edm. Halley, LL. D. and Secretary to the Royal Society.

**T**HIS wonderful luminous *Meteor* which was seen in the Heavens on the 19th of *March* last, as it was matter of Surprize and Astonishment to the Vulgar Spectator, so it afforded no less Subject of Enquiry and Entertainment to the speculative and curious in Physical things: Some of its *Phænomena* being exceeding hard to account for, according to the Notions hitherto received by our Naturalists; such are the very great Height thereof above the Earth; the vast Quantity of the Matter thereof; the extravagant Velocity wherewith it moved; and the prodigious Explosions thereof heard at so great a Distance, whose Sound, attended with a very sensible Tremour of the subject Air, was certainly propagated through a *Medium* incredibly rare and next to a *Vacuum*.

In Num. 341. of these *Transactions*, I have collected what I could find of such-like *Meteors*, and since, turning over the *Ephemerides* of *Kepler*, I accidentally hit upon another, prior to all those there described, and which was seen all over *Germany*. Of this the Words of *Kepler* are: *Die 27. Nov. 1623. Meteorum ignitum, Globus ardens ab occasu in ortum volans totâ passim Germaniâ fuit conspectus. In Austria etiam fragorem exaudium affirmarunt quasi à fulmine; quod vanum tamen puto: nihil enim tale confirmant descriptiones quæ extant.* Yet  
 \* neither

neither this, nor any of the other hitherto described, seem to come up in any Circumstance to this late Appearance; of which I am in hopes to give a satisfactory Account, being enabled by the very many Relations thereof communicated to the *Royal Society*, from most parts of the Kingdom; tho' it was not my good Fortune to see it my self; and tho' very few of our Countrymen who best know the *Stars*, had better luck. Some of the most perfect Descriptions we have receiv'd are the following:

*First*, Our very worthy Vice-President Sir *Hans Sloan*, Baronet, being abroad at that time, happen'd to have his Eyes turned towards it, in its very first Eruption; and the next Day he was pleas'd to give me in Writing what he had with great Exactness noted about it, in the Terms following: " On *Thursday, March 19. 17<sup>th</sup>*,  
 " passing along Eastward by the N E. Corner of *Sou-*  
 " *thampton-street in Bloomsbury-Square, London*, at about  
 " a Quarter after Eight at Night, I was surpriz'd to  
 " see a sudden great Light, much beyond that of the  
 " Moon, which shone then very bright. I turn'd to  
 " the Westward where the Light was; which I apprehended at first to be artificial Fire-works or Rockets.  
 " The first place I observ'd it in, was about the *Fli-*  
 " *ades* Northerly, whence it moved after the manner,  
 " but more slowly than a falling Star, in a seeming  
 " direct Line, descending a little beyond, and withal  
 " below, the Stars in *Orion's Belt* then in the S. W.  
 " The long Stream appear'd to me to be branched about  
 " the middle, and the *Meteor* in its way turn'd Pear-  
 " fashion'd or tapering upwards. At the lower end it  
 " came at last to be bigger and Spherical, tho' it was  
 " not so big as the Full Moon. The Colour of it was  
 " whitish, with an eye of Blue, of a most vivid daz-  
 " ling Lustre, which seem'd in Brightness very nearly



“ to resemble, if not surpass that of the Body of the  
 “ Sun in a clear Day, beheld by the naked Eye This  
 “ Brightness obliged me to turn my Eyes ( which had  
 “ their Pupils adapted to the Light of the Moon ) from  
 “ it several times, as well when it was a Stream. as  
 “ when it was Pear-fashion’d and a Globe: tho’ I had  
 “ a great Curiosity to observe it with Attention It  
 “ seem’d to move in about half a Minute or less, about  
 “ the Length of  $20^{\circ}$ , and to go out. as I guess’d, about  
 “ as much above the Horizon. There was left behind  
 “ it, where it had pass’d, a Track of a cloudy or faint  
 “ reddish Yellow Colour, such as red-hot iron or glow-  
 “ ing Coals have, which remained more than a Minute,  
 “ seem’d to sparkle, and kept its Place without falling.  
 “ This Track was interrupted, or had a Chaim towards  
 “ its upper end, at about two Thirds of its Length. I  
 “ did not hear any Noise it made, but the place where  
 “ the Globe of Light had been, remain’d after it was  
 “ extinct, of the same reddish Yellow Colour with the  
 “ Stream for some time, and at first some sparks seem’d  
 “ to issue from it, such as come from red-hot Iron bea-  
 “ ten on an Anvil. The Surprise, Brightness of the  
 “ Light, and Noise of the People upon the Variations  
 “ of the Appearance, calling to one another to observe  
 “ what they never had observ’d in their Days, and  
 “ thought to be prodigious, hinder’d me from taking  
 “ notice or remembring any thing farther about it.

It were to be wisht that Sir *Hans* had more especial-  
 ly regarded the Situation of the Track of this Meteor  
 among the fixt Stars, and let us know how much it  
 pass’d above the *Pleiades*, and how much under the *Belt*  
 of *Orion*, that so we might with more Certainty have  
 determin’d its Position in respect of the Horizon of  
*London*; for which purpose the whole Number of Spe-  
 ctators there has not furnish’d us with one sufficient  
 Observa-

Observation: But all the Relations, however otherwise differing, agree in this, that the Splendour was little inferior to that of the Sun; that within doors the *Candles* gave no manner of Light, and in the Streets not only all the *Stars* disappear'd, but the *Moon* then Nine Days old, and high near the Meridian, the Sky being very clear, was so far effaced as to be scarce seen, at least not to cast a Shade, even where the Beams of the Meteor were intercepted by the Houses: so that for some few Seconds of Time, in all respects it resembled perfect Day.

The Time when this happen'd was generally reckoned at a quarter past Eight; but by the more accurate Account of the Rev. Mr. *Pound* ( who only saw the Light ) agreeing with what has been sent us from the *Parisian* Observatory, it appears to have been at 8<sup>h</sup> 8' apparent Time at *London*. And the Sun being then in 9 $\frac{1}{2}$  gr. of *Aries*, the Right Ascension of the Mid-Heaven was 130 gr. 45', whereby the Position of the Sphere of fixt Stars is given. Hence the *Lucida Pleiadum* will be found at that time to have been 25 $\frac{1}{4}$  gr. high, in an *Azimuth* 6 gr. to the Northward of the West, and consequently the Arch the Meteor moved in, was inclined to the Horizon with an Angle of about 27 gr. having its Node or Intersection therewith, nearly *South South West*; as will be more evident by what follows.

At *Oxford* five Minutes earlier, Mr. *John Whiteside*, R. S. Soc. Keeper of the *Ashmole Museum*, and very skilful in both Mathematical and Physical Matters, immediately after the Extinction of the Meteor, made haste out to see what it might be, and well consider'd the Situation of the Track it had left in the Sky: He found it to have past about 1 $\frac{1}{2}$  Degree above the preceding Shoulder of *Orion*, and about 3 $\frac{1}{2}$  gr. above

the middle of his *Belt*, where there appear'd a luminous *Nubecula* of a reddish Light, being a Dilatation of the Track, seeming to have been occasion'd by some Explosion there; and by what he could learn from those that saw it, it was thereabout that it broke out, and first began to efface the Stars. Hence it proceeded as to sense in an Arch of a great Circle, and passing in the middle between the Tail of *Lepus* ( $\theta$  *Bayero*) and  $\beta$  in the Fore-Foot of *Canis major*, it terminated about  $\xi$  in the Breast of the same, nearly in 95 gr. of Right-Ascension, with 23 gr. South Declination: and at the place of its Extinction there remained a large whitish *Nebula*, much broader and of a stronger Light than the rest of the Track, which he took for a certain Indication of a very great Explosion made there. By Computation it will be found that the Angle this Track made with the Horizon of *Oxford* was nearest 40 gr. and its Intersection due *SSW*; and that the place of its Extinction was about 9 gr. above the Horizon, in the Azimuth of 32 gr. to the *West*.

At *Worcester* Mr. *Nicolas Fatio*, a Person greatly skill'd in Astronomical Affairs, saw this Meteor descend obliquely towards the *South*, making an Angle with the Horizon of about  $65^\circ$ , and intersecting it about *SSW*  $\frac{1}{2}$  *S*, as may be collected from a Scheme thereof sent up by him, and communicated to the *Royal Society*, seeming to be design'd with sufficient Exactness. By this the Track left all *Orion* and *Canis major* to the Westward, and divided the Distance between *Sirius* and *Procyon*, so as to be almost twice as far from *Procyon* as *Sirius*. The Time here was one Minute before Eight, this City being about 9' of Time to the West of *London*, and consequently the Right-Ascension of the Mid-Heaven 128 $\frac{1}{2}$  gr.

Now

Now the Situation of the three Cities *London*, *Oxford*, and *Worcester* being nearly on the same *W.N.W.* Point, whereon the Track of the Meteor had its greatest Altitude above the Horizon, equal to the Angle of its visible Way; if we suppose it at *London* to have been 27 gr. high, and at the same time at *Worcester* to be 65 gr. high, in the Plane of the Vertical Circle passing through *London* and *Worcester*; supposing likewise the Distance between them to be 90 Geographical Miles, or one Degree and half of an Arch of a great Circle of the *Earth*, we shall by a Trigonometrical Calculus, too obvious to be here inserted, find the perpendicular Height to have been 64 such Miles; and the Point over which it was then perpendicular to have been 30 such Miles *W.N.W.* from *Worcester*. And the Geographical Mile to the *English* Statute Mile being as 23 to 20, this Height will be no less than  $73\frac{1}{2}$  *English* Miles. The place also directly under it, will be found to be about *Prestain* on the Confines of *Hereford* and *Radnor-Shires*. Nor can we be much out in this Determination, the *Oxford* Observation concurring nearly in the same Conclusion.

This Altitude being added to the Semidiameter of the *Earth* as *Radius*, becomes the *Secant* of Eleven Degrees, so that the Meteor might be seen above the Horizon in all Places not more than 220 Leagues distant from it. Whence it will not be strange that it should be seen over all Parts of the Islands of *Great Britain* and *Ireland*, over all *Holland* and the hither Parts of *Germany*, *France* and *Spain*, at one and the same instant of Time.

This suggests a very great use that might be made of these momentaneous *Phænomena*, to determine the *Geographical Longitudes* of Places. For if in any two Places two Observers, by help of *Pendulum Clocks* duly corrected  
by,

by Cœlestial Observation, do exactly note at what Hour, Minute and Second such a Meteor as this blows up and is extinguish'd, the Difference of those Times will be the Difference of Longitude of the two Places, as is well known. Nor does it require so much as the Use of a *Telescope*, as in the Methods hitherto put in practice for that purpose: so that if these Appearances could be predicted, and Notice given of their coming, that we might know when to expect them, I should make no Difficulty to prefer this way of settling the *Geography* of a Country before all others.

Having thus fixt one Point in the Line of its Motion, let us now consider what course the Meteor took from thence. And first at the Town of *Kirby-Stevens*, on the Borders of *Yorkshire* and *Westmoreland*, in a Meridian very little to the Westward of *Worcester*, but about  $2\frac{1}{2}$  gr. more to the North, it was observed to break out as from a dusky Cloud, directly under the Moon, and from thence to descend, nearly in a Perpendicular, almost to the Horizon. Now the Moon, being at that time in the third Degree of *Leo*, was about half an hour past the Meridian, and consequently much about a point to the West, or *S b W*: and the Situation of *Prestain* from *Kirby-Stevens* being sufficiently near upon the same Point, it follows that the Direction of the Track of the Meteor was according to the Great Circle passing over those two Places.

And this is further confirm'd by the Observation of *Sam. Cruys*, Esq; *Reg. Soc. Soc.* who at *Tiverton*, about twelve Geographical Miles nearly due North from *Exeter*, observed the first Explosion of this Meteor exactly in his Zenith, as he was assured by applying his Eye to the side of his Door, which he took to be perpendicular, and looking upwards: And from thence he saw it descend to the Southwards directly in the same

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Azimuth, without declining either to the Right or Left: Hence it is plain, that the Track likewise pass'd over this place, which by our best Maps is found to lie in a Line with *Preftain* and *Kirby-Stevens* with sufficient Exactness; so that we shall take it for granted that this was the very Course it held.

On this Supposition, that the first Explosion attended with the reddish *Nubecula*, was directly over *Tiverton*, we have the *Oxford* Observation to compare with it, in order to determine more nicely the perpendicular Altitude there. At *Oxford* this *Nubecula* was found to be  $3\frac{1}{2}$  gr. above the middle Star of *Orion's Girdle*, at  $8^h 3'$ , and was therefore  $26\frac{1}{2}$  gr. above the Horizon; and the Distance between *Oxford* and *Tiverton*, being  $1^{\circ} 55'$  or 115 Geographical Miles, it will be as the Sine of  $61^{\circ} 35'$  to the Sine of  $63^{\circ} 30'$ . So the Semidiameter of the Earth being  $3437\frac{1}{2}$  such Miles, to 3498 Miles the Distance of the Meteor from the Center of the Earth; from which deducting the Semidiameter, there remains  $60\frac{1}{4}$  Geographical Miles for the Height of the Meteor above *Tiverton*: And that this was so is confirmed by the Observation of the Rev. Mr. *Will. Derham*, who at *Windsor* saw the afore-said *Nubecula* about two Degrees above the most Southerly of the Seven Stars in the Shield of *Orion*; that is (the Time being  $8^h 6'$ ) in the Altitude of  $23\frac{1}{2}$  gr. whence, the Distance between *Tiverton* and *Windsor* being 150 measured Miles, or 130 Geographical. by a like Proportion we shall find the same Height of the Meteor  $60$  such Miles wanting only one Quarter. So that in a round Number we may conclude it to have been just 60 Geographic or 69 Statute Miles above the Earth's Surface. Nor is it possible to come at a precise Determination of this matter, by reason of the Coarseness and Inaccuracy of our Data, which were only

only the Notes of Persons under the Surprize of the suddenness of the Light, and no ways pretending to Exactness; however, such as they are, they abundantly evince the Height thereof to have exceeded 60 *English* Miles, not to say 38 or 40, as some would fain have it.

I was unwilling to leave off, till I had pitcht upon some Hypothesis that might subject the Motion of this Meteor to a *Calculus*, that the Curious might be able to compute the visible way thereof, either in respect of the Horizon or among the fixt Stars: This I found might be done with tolerable Exactness, supposing that it mov'd in the Arch of a Circle concentrick with the Earth, but 60 Geogr. Miles without it; and that the Point of the first Explosion was over the Lat. of  $50^{\circ} 40'$  and  $3^{\circ} 40'$  to the West of *London*; and that of the last Extinction over Lat.  $47^{\circ} 40'$  with  $4^{\circ} 50'$  *West* Longitude: The Time being fixt to 8 Minutes past Eight at *London*. Hence it will be easy, by a Trigonometrical Process, to obtain the visible Altitude and Azimuth of the Meteor at either of its Explosions, as seen from any Place whose Longitude and Latitude is known; and from the Time given, the Points in the Sphere of Stars answering to those Azimuths and Altitudes are readily deduced. Let those that contend for a much less Height of this Meteor try if they can on such their Supposition reconcile the several *Phænomena* before recited with one another, and with the Observation of the Rev. Mr. *William Ella*, Rector of *Fampton* in *Nottinghamshire*, between *Gainsborough* and *Redford*, which for its Exactness I must not omit. Here at  $8^h 5'$  the Meteor was seen to pass precisely in the middle between *Sirius* and the Fore-Foot of *Canis major*, moving obliquely to the Southward, in a Line whose Direction seem'd to be from the middle between

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the

the two Shoulders of *Orion*. The Latitude of the place being nearly  $53^{\circ} 20'$ , and Longitude *West* from *London*  $0^{\circ} 45'$ . Let them try how they can account for its being seen five Degrees high at *Aberdeen* in *Scotland*, and near as much at *Peterhead* half a Degree more Northerly : and then they will be better able to judge whether it did not exceed the reputed Limits of our Atmosphere. Lastly, if the apparent Altitude of the Meteor at *Paris* was not  $5\frac{1}{2}$  but  $11$  gr. on the *W b N* Point, when it must have been in its greatest Lustre, there will be no pretence to bring it lower than I have made it, especially if it be allowed to have follow'd the Track I have assign'd it, over *Prestain*, *Cardiff*, *Minhead*, *Tiverton*, and *Brest* in *Bretany*.

Allowing this to have been the Path it mov'd in, it would be easy to assign the real Magnitude and Velocity of this Meteor, if the several Accounts of its apparent Diameter, and of the Time of its Passage from one of its Explosions to the other, were consistent with themselves. But some of them making its visible Appearance nearly equal to the Sun's, which in the Opinion of many it far exceeded, we may suppose with the least that, at the time when it first broke out over *Tiverton*, its Diameter was half a Degree. And its Horizontal Distance being  $150$  Geogr. Miles from *London*, and its Altitude  $60$ , the Hypothenuzal or real Distance from the Eye will be more than  $160$  such Miles ; to which Radius the Subtense of half a Degree will be above an English Mile and half, being about  $2800$  Yards *quàmproximè*. After the same manner it is difficult to assign its due Velocity, whilst some make it half, others less than a quarter, of a Minute, in passing from its first Explosion to its last Extinction : But the Distance it moved in that time being about  $3$  gr. or  $180$  Geogr. Miles, we may modestly compute



it to have run above 300 such Miles in a Minute ; which is a Swiftneſs wholly incredible, and ſuch, that if a heavy Body were projected horizontally with the ſame, it would not deſcend by its Gravity to the Earth, but would rather fly off, and move round its Center in a perpetual Orb, reſembling that of the *Moon*.

Of ſeveral Accidents that were reported to have attended its Paſſage, many were the effect of pure Fancy ; ſuch as the hearing it hiſs as it went along, as if it had been very near at hand : others imagined they felt the Warmth of its Beams ; and ſome there were that thought, at leaſt wrote, that they were ſcalded by it. But what is certain, and no way to be diſputed, is the wonderful Noiſe that follow'd its Exploſion. All Accounts from *Devon* and *Cornwal* and the neighbouring Counties are unanimous, that there was heard there, as it were the Report of a very great Cannon, or rather of a Broad ſide, at ſome diſtance, which was ſoon follow'd by a rattling Noiſe, as if many ſmall-Arms had been promiſcuouſly diſcharged. What was peculiar to this Sound was, that it was attended with an uncommon Tremour of the Air, and every where in thoſe Counties, very ſenſibly ſhook the Glaſs-Windows and Doors in the Houſes, and according to ſome, even the Houſes themſelves, beyond the uſual Effect of Cannon, though near ; and Mr. *Crunys* at *Tiverton*, on this occaſion, loſt a Looking-Glaſs, that being looſe in its Frame, fell out on the ſhock, and was broken. Nor do we yet know the Extent of this prodigious Sound, which was heard, againſt the then Eaſterly Wind, in the Neighbourhood of *London*, as I am inform'd ; and by the Learned Dr. *Tabor*, who diſtinctly heard it beyond *Lewis* in *Suffex* : So that I cannot help thinking, that ſuch a Meteor as this might have occaſion'd that famous Ode of *Horace* :

*Parcus Deorum cultor, &c.*

\*

——— *Namque*

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— *Namque Diespiter*

*Ignе corusco nubila dividens*

*Plerumque, per purum tonantes*

*Egit equos volucremque currum,*

*Quo bruta tellus, &c. Concutitur.*—

But whether the Report heard near *Levis* were of that Exploſion right over *Devonſhire*, or rather of that latter and much greater at the Extinction over *Britany*, I ſhall not undertake to determine, till we have ſome further Accounts from *France*, whence hitherto we have only had, that at *Paris* the Time of the Appearance was at 17 Minutes paſt Eight.

It remains to attempt ſomething towards a Solution of the uncommon *Phænomena* of this Meteor; and by comparing them with things more familiar to us, to ſhew at leaſt how they might poſſibly be effected. And firſt the unuſual and continu'd Heats of the laſt Summer in theſe Parts of the World, may well be ſuppos'd to have excited an extraordinary Quantity of Vapour of all ſorts; of which the aqueous and moſt others, ſoon condens'd by Cold, and wanting a certain Degree of Specifick Gravity in the Air to buoy them up, aſcend but to a ſmall Height, and are quickly returned in Rain, Dews, &c. whereas the inflammable ſulphureous Vapours, by an innate Levity, have a ſort of *Vis centrifuga*, and not only have no need of the Air to ſupport them, but being agitated by Heat, will aſcend in *Vacuo Boileano*, and ſublime to the top of the Receiver, when moſt other Fumes fall inſtantly down, and lie like Water at the bottom; the Experiment whereof was firſt ſhewn me by the Reverend Mr. *Whiteſide* at *Oxford* and was very lately made before the *Royal Society*. By this we may comprehend how the matter of the Meteor might have been raiſed from a large Tract of the Earth's Surface, and aſcend far above the reputed Limits of the *Atmoſphere*; where, being diſengaged from all other Particles, by that principle of Nature that congregates *Homogenia* viſible in ſo many Inſtances, its

Atoms

Atoms might in length of time coalesce and run \* *fortuitously* together, as we see Salts shoot in Water; and gradually contracting themselves into a narrower compass, might lie like a Train of Gunpowder in the *Ether*, till catching fire by some internal Ferment, as we find the Damps in Mines frequently do, the Flame would be communicated to its continued parts, and so run on like a Train fir'd.

This may explain how it came to move with so unconceivable a Velocity; for if a continu'd Train of Powder were no bigger than a Barrel, it is not easy to say how very fast the Fire would fly alongst it; much less can we imagin the Rapidity of the Accension of these more inflammable Vapours, lying in a Train of so vast a Thickness. If this were the Case, as it is highly probable, it was not a Globe of Fire that ran along, but a successive kindling of new Matter: and as some parts of the Earth might emit these Vapours more copiously than others, this Train might in some parts thereof, be much denser and bigger than in others, which might occasion several smaller Explosions, as the Fire ran along it, besides the great ones which were like the blowing up of Magazines. Thus we may account for the rattling Noise like small-Arms, heard after the great Bounce on the Explosion over *Tiverton*; the Continuance of which for some time, argues that the Sound thereof came from Distances that encreased.

What may be said to the Propagation of the Sound thro' a *Medium*, according to the receiv'd Theory of the Air above 300000 times rarer than what we breath, and as I said before, next to a *Vacuum*, I must confess I know not. Hitherto we have concluded the Air to be the Vehicle of Sound; and in our artificial *Vacuum* we find it greatly diminish'd: but we have this only Instance of the effect of an Explosion of a Mile or two diameter, the immensity of which may perhaps compensate the extream Fineness of the *Medium*.

**F I N I S.**

\* Dele *fortuitously*.

# PHILOSOPHICAL TRANSACTIONS.

For the Months of June, July and August, 1719.

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- I. *An Observation of the end of the Total Lunar Eclipse on the 5th of March 1718. observed near the Cape of Good Hope, serving to determine the Longitude thereof. With Remarks thereon. By E. Halley, R. S. Secr.*

THIS now better than thirty Years since I had a Dispute with some of the *French Geographers* about the Longitude of the Cape of Good Hope, said to have been observ'd by the Religious Missionaries sent to *China* in the Year 1685. By an Emerſion of the first Satellite of *Jupiter*, they determined that Cape to be  $1^{\text{h}}. 11'$  or  $17\frac{3}{4}$  grad. more Easterly than *Paris*, that is 20 grad. from *London*; which for the reasons I then gave, I concluded could not be more than 17 grad. See *Phil. Transact.* N<sup>o</sup> 185. Very lately I have fallen upon an Observation which I believe will determine the Controversy in my favour: for I had accidentally a Journal of an Officer of the Ship *Emperor* put into my Hands, who in his return from *India*, on the fifth of *March 1718.* observ'd the End of a Lunar Eclipse, when the visible altitude of the Moons Centre was  $13^{\circ}. 25'$ . he being then in the Latitude of  $34^{\circ}. 23'$  South, and as they found afterwards, just 180 Leagues to the Eastwards of Cape *Bonne Esperance*. By Calculation I find that in that Latitude the Moon had that height at  $7^{\text{h}}. 17\frac{1}{2}'$  P. M. and by comparing this Eclipse with that we observ'd with great exactness on *Febr. 11<sup>o</sup>. 1682.* (which agrees perfectly well with our Numbers) I conclude the middle of this to have been at *London* at  $3^{\text{h}}. 48'$  P. M. To which adding  $1^{\text{h}}. 46'$  for the

the Semiduration (this being very certain from the observ'd Continuance of the Eclipse of 1682.) the End will be found to have been at *London* at 5<sup>h</sup>. 34'. The Ship was therefore in a Meridian 26° to the Eastwards of *London*: But she was at that time 180 Leagues to the Eastwards of the *Cape*, which distance in that Latitude gives eleven Degrees of Longitude; this therefore being deducted from the Longitude of the Ship, leaves just 15 *grad.* or one Hour, for the difference of Meridians between *London* and the *Cape*. So that by this account the *Cape* is yet nearer our Meridian than I had formerly made it, and near six Degrees nearer than *M. De la Hire* places it in his *Tables*.

This Eclipse was attended with all the Circumstances requisite to make the Conclusion as certain as the nature of the thing will admit of: For the Moon was nearly in *Perigæo*, and the Eclipse almost central; for which reasons she emerged out of the Shadow as swiftly as possible: The Sea was very smooth, there having been little Wind for above 30 Hours before; and the Moon was not too high to be well observed with a Forestaff. Nor were they long at Sea before they made the Land, for in less than five Days, on the tenth of *March* at Noon, they had past *Cape d'Agulhas* the most Southerly Promontory of *Africa*, which then bore from them *North East*, about seven Leagues distant. The End of this Eclipse, though not visible here, might have been seen in *Germany*, both at *Nuremburg*, *Leipsick* and *Berlin*, but we cannot learn that it was any where observed there; however our Numbers in this Case may be securely relied on.

On this occasion it may not be amiss to insert an Observation or two I procured to be made at the *Cape*, by *Mr Alexander Brown* a *Scotch* Gentleman, who went to reside in *India* on our Companies account. He carried  
with

with him a very good *Brass Quadrant* of above two Foot Radius, and at the *Dutch Settlement* at *Table Bay*, having rectify'd his *Pendulum-Clock* by correspondent Altitudes, on the 4th of *August* 1694, at 5<sup>h</sup>. 59' *Manè*, the distance of the bright Limb of the Moon from the right Shoulder of *Orion* was observ'd to be 25° 3'. And the next Morning *Aug*. 5. at 5<sup>h</sup>. 21'. 12", the same Limb was distant from *Procyon* 25°. 57', and at 5<sup>h</sup>. 36'. 48" from the *Lucida Arietis* 58°. 29'.

It were much to be wish't that the Moon had, either of these Mornings, been accurately observ'd at *Greenwich* or *Paris*, or at some Place in *Europe*, whose Longitude from them is well known. But that failing us, I had recourse to the Period of the Lunar Motions, which is perform'd in 18 Years and ten or eleven Days, after which the Errors of our Lunar Computations return very nearly the same; and I found among my own old Observations, one that tally'd well with that of the 4th of *August*. *Viz.* Anno 1676. *July* 23°. 13<sup>h</sup>. 11'. 35". at *Oxford*, I observ'd the Moon to apply to the Star *in medio Collo Tauri*, by *Bayer* markt *A*. The Star at that time was distant from the Southern and nearest Cusp of the Moon by the Micrometer 20'. 32". and at 13<sup>h</sup>. 17'. 15". when it seem'd to immerge upon the bright Limb of the Moon, it was distant from the Northern Cusp 23'. 20"; but this less certain by reason of the hazey Air. The Star at that time was in  $\approx$  28°. 56'. with 1°. 13'. 20". *North Lat.* whereby I found that our Lunar Tables, founded on Sir *Isaac Newton's* correct Theory of her Motion, gave her place at that time only two Minutes too slow; which Error being allowed on the 4th of *August* 1694. the result was, that 5<sup>h</sup>. 59'. at *Cape Bonne Esperance* was at *London* 4<sup>h</sup>. 53'. whence the difference of Longitude 16½ degrees, sufficiently near what we had before determin'd.

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## II. JACOBI KEILL, M.D. *De Viribus Cordis Epistola.*

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Viro Celeberrimo

RICHARDO MEAD, M.D.

S. P. D.

*Jacobus Keill.*

**E**PISTOLAM D. *Jurin*, Tibi, Vir Clarissime, inscriptam, in Actis Philosophicis nuper publicatam legi; in quâ, ea quæ à me traduntur de viribus Cordis, infirmare conatur vir Doctissimus. Cum æstimatio virium, quibus Cor Sanguinem expellit, à *Borellio* facta, fere omnibus valde incredibilis videbatur, non me temerarium, non *Borelli* nomini injuriosum, non orbi literato ingratum facturum existimavi, si ad verum propius accedere tentarem. In quo Tentamine, non accuratam virium Cordis definitionem mihi propositum erat dare, sed potius methodum, quâ hæ vires forte inveniri possent, indicare; & Geometriæ peritiores ad Problematis valde desiderati investigationem incitare. Quo animo tentamen illud primum suscepi, eodem ea, quæ in eo reprehendit vir Doctissimus, nunc defendam Ne-

9 P

quaquam



quaquam enim mihi honorem quaero (utcumque parva mea existimatio sit, est certe debito major) sed Genti Medicæ lucem undecumque illatam gaudeo. Idcirco non ut Decreta mea sustineam, sed ut vir huic negotio plusquam par, suas demonstrationes secum reputare, & Reipublicæ Literariæ correctiores denuo reddere dignetur, hanc Tibi scripsi literam. Quem enim Adversarius Patronum sibi ambivit, ego Te judicem Controversiæ intelligentem & æquissimum mehercule exopto.

Præcipuum quod *Borellio*,—*D. Moreland*, mihi objicit vitium est, quod in Potentiâ Cordis æstimandâ, quam rationem ad pondus iners, vel corporis gravitatem obtineat, determinare suscepimus. “Sed Cor, inquit, cum & ipsum inter contrahendum movetur, & corpora opposita, Sanguinem nempe & arteriarum tunicas in motum impellit, patet ejus *Potentiam* non aliâ ratione sciri posse quanta sit, quam ut motus hujus quantitatem cognitam tencamus. *Motus* autem qui libet cum pondere quiescente comparari non magis potest, quàm linea cum rectangulo.” At à nemine certè nostrum, quod scio, est *Motus* Cordis cum pondere quiescente comparatus. *Potentiam* autem Cordis, seu vim Cordis motricem & Sanguinem impellentem cum pondere conferre, quid prohibet non video. Quamquam enim inter *Pondus* & *Motum* corporis solidi nulla sit relatio, vis tamen motrix, si in fluidum agit, ad vim gravitatis quandam certe rationem habet. Et revera vis corporis motrix, certam in fluido motûs quantitatem in dato tempore efficiens, æqualis est ponderi, quod vi gravitatis cadendo, in eodem tempore, eandem motûs quantitatem sibi acquirit. Hinc vis, quâ ex officio aliquo aqua expellitur, certo pondere æqualis esse dicitur: quia pondus datum, & vis aquam exprimens æquales motus in temporibus æqualibus generant.

nerant. Hic genuinus Corollarii *Newtoniani* sensus mihi videtur esse, nec ab hoc sensu discrepant, quæ de Cordis viribus explicui Verba *Newtoni* sunt, *Vis, quæ totus aquæ exsurgentis motus generari potest, æqualis est ponderi &c.* quæ non satis attendisse videtur *Jurinius*, cum dicit *Pondus autem illud quo motus aquæ ex vase effluentis generari potest, &c.*

Sed si hæc re à nobis peccatum est, cum summis certe hujus sæculi Geometris *Hugenio* & *Newtono* peccavimus, quorum uterque vim fluidorum per vim gravitatis exponit. Nec in *Corol.* prædicto id solummodo facit *Newtonus*, sed in aliis etiam locis ostendit Methodum, quâ ratio resistentiæ Medii, id est, actionis fluidi in corpus solidum, ad vim Gravitatis vel centripetam inveniri potest, ut videri licet in *Prop. 4ta* & *5ta* Libri secundi, eorumque Corollariis. Alia profecto est actio fluidorum in solidum, & alia solidorum in se invicem. Fluidum datâ velocitate motum, datum pondus sustinere potest, cum fluidi partes sibi mutuo continuo succedentes in pondus impingunt, adeoque vis fluidi est revera ponderi æqualis; sed cum Solidorum non par est ratio, eorum Vis cum Gravitate comparari nequit.

Me insuper reprehendit Vir ingeniosissimus, quod velocitatem Sanguinis è corde detrusi, per totam systolem æqualem posui, quam ille valde inæqualem esse demonstravit. Verum à me nusquam Sanguini æqualis data est velocitas, sed pro summâ omnium velocitatum mediam posui. Sed utrum æqualis vel inæqualis est Sanguinis è Corde ejecti celeritas, nondum satis mihi constat; certe quæ pro æquali velocitate stat ratio, ea mihi in præsens firmior videtur.

Sic emaculatis vitiis quæ in primâ nostrâ methodo reprehendit vir Cl: quid in alterâ quæ subjuncta est, illi displicet, videamus. Et est certe assumptio illa quæ à *Borellio*, aliisque viris doctis sæpius usurpata est,

nempe, quod similibus musculorum vires sunt in ratione ponderum. Aliam virium rationem in Theoremate 5to stabilire conatur *Jurinius* : sed cum ex communi omnium suorum Theorematum Principio oritur demonstratio, communi etiam eorum fato involvetur : Si enim principium illud fallax est, (ut mihi videtur) nec ad casus ad quos adhibetur, congruit ; corruunt certe omnia, quæ hæc basi innituntur. Supponit Vir Clarus : Vasorum tunicas in Sanguinem intus contentum impetu irruere, & motus sui partem Sanguini ictu communicare : & hæc in motu Cordis, vult Ventrículum tanquam solidum Corpus, datâ velocitate motum, in Sanguinem impingere, & ictu motus sui partem illi impertire : quæ suppositio nec Sanguinis nec Cordis, nec Aeris è Pulmone expressi motui competit, nec ullâ minimorum ictuum reiteratione, horum motibus ita accommodari potest, quin quæ inde deducuntur conclusiones pro incertis & omnino falsis haberi debeant.

Cum inter Sanguinem & Cordis intimum nullum intercedit spatium, sed est alter alteri contiguus, non ictu hoc in illum, sed pressu agit : nec ullam in initio suæ contractionis celeritatem ventriculi habent, sed se contrahendo velocitatem tempore acquirunt, tanquam gravia cadendo, vel ut fluida rarecendo, ex quo forte omnis vis Cordis oritur. Adeoque non æquabilis est motus contractionis, ut vult Vir Doctissimus, sed est motus instar cadentis acceleratus. Idem igitur est discrimen inter ictum, quo Cor Sanguinem ferire vult *Jurinius*, & pressuram quâ Cor revera in Sanguinem agit, quod est inter actionem corporis solidi moti, & vim gravitatis : sed ipso fatente, hæc comparari nequeunt, adeoque pressura seu actio cordis in Sanguinem per ictum nec à Viro laudato exposita est, nec unquam exponi potest. Hanc sententiam confirmat ipsa Cordis potentia à Viro Cl. inventa. Si enim pondus datâ velocitate motum,  
cordis

cordis potentix æquale esset, tunc Sanguis omni vi Cordis in pondus illud directe impulsus motum ponderis temporis momento destrueret : sed quocunque magno imperu ponderi occurrat Sanguis, nunquam illi omnem motum in instanti eripiet, adeoque est hoc pondere potentia Cordis minor, nec recte per motum ponderis vires Cordis exponuntur.

Fluidorum vires in corpora solida, ubique eodem prorsus modo quo solidorum vires in se invicem, *Jurinus* æstimat & perpendit, cum tamen maxima intersit differentia; & ab hoc capite fluit quicquid est in illius Propositionibus erroris. Ubi enim corpus solidum, cujus partes firmiter inter se cohærent, in aliud impingit, unaquæque corporis particula simul & semel suam alteri vim impertit : at res aliter se habet in fluidis, in quibus nulla est partium cohærentia, nulla fluidi pars, nisi in ipso tactu, in corpus sibi oppositum agit : idcirco cum columna aquæ adversus corpus solidum sursum vertitur, partes columnæ à corpore remotiores nullam illi vim imprimunt. Corpus etiam solidum unicum solummodo ictum alteri communicat; at columna fluidi in corpus sibi oppositum continue agit, & minima columnæ pars minimo temporis momento, ictum infinite parvum illi imprimit, eodem prorsus modo quo gravia cadendo agunt, quibus igitur fluidorum motus recte comparatur. Porro omnis motus corporis solidi in alterum directe impingentis in temporis momento destrui potest : sed motus solidi vim fluido imprimentis, non nisi gradatim imminuitur, & in dato tempore evanescit, pari ratione, quâ Gravitas in corpus sursum missum vim suam exerit. Ex quibus satis abunde constat, inter vim fluidi in motum acti, & vim gravitatis magnam esse affinitatem, & unam per alteram recte exponi posse; vim autem corporis solidi ad vim gravitatis referri non posse. Cumque hanc differentiam

rentiam non satis attendisse videtur Doctissimus *Jurinus*, à vero multum aberrasse mihi videtur. Si igitur sepositâ suâ, de Vasorum ictu, hypothesi, & vi pressuræ, quâ Natura utitur, pro Principio adhibitâ, alia Theoremata de Cordis & Sanguinis motu & viribus, eleganter suâ demonstrationis methodo, construere dignabatur, sese dignum, mihi certe gratum, nec eruditis inutile præstiterit. Tu, qui Rei Medicæ principatum tenes, Vir Amplissime, dissentientium disputationes tuâ prudentiâ ita moderari digneris, ne Indoctis ludibrio, sed ut Doctis emolumento esse possint. Dabam *Norhamptonæ* 23. die *Junii* 1719.

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III. *An account of some Experiments relating to the Specifick Gravity of Human Blood.* By James Jurin, M. D. and F. R. S.

**I**T is well known from the Observations of Mr. *Leeuwenhoek* and others, that Human Blood consists of red globular Particles, swimming in a pellucid *Lympha*, or *Serum*. Which two different Substances, tho' of unequal Specifick Gravities, yet so long as they continue to circulate in the Veins and Arteries, are prevented from separating by their Motion and Warmth. But when the Blood comes to stagnate and cool in a Porringer, the globular Particles uniting together by their attractive Power, and sinking by their Weight, which is greater than that of the *Serum*, form the *Coagulum*, or *Crassamentum*, at the bottom of the Porringer, the *Serum* swimming above it.

Things always happen in this manner, when the *Crassamentum* is at liberty to subside: but it often falls out, that, either by its adhesion to the sides of the Vessel, or by the bubbles of Air, which the Blood

\* gathers

gathers upon falling into the Porringer, and which stick to it's Surface, the *Craffamentum* is kept from sinking, and seems to float upon the top of the *Serum*.

These Accidents seem to have given the first occasion to that Opinion, which, I think, has been generally entertain'd by those who have writ upon this Subject, namely, that the globular part of the Blood is specifically lighter than the *Serum*, in which it swims.

But that which has so fully establish'd this persuasion, is the Authority of the late excellent Mr. *Boyle*, who, among the many valuable and curious Experiments he has given us in his Natural History of Human Blood, has left the following ones upon this Subject.

The specifick Gravity of *Serum* of Human Blood was found by weighing a piece of Sealing Wax first in *Serum*, and afterwards in Water, to be to the specifick Gravity of Water, as 1024 to 1000.

In a second Experiment, which for greater accuracy was made with an Instrument contriv'd on purpose, the specifick Gravity of *Serum* was found to be to that of Water, as 1194, to 1000.

In a third Experiment made by the same Instrument, and with *Serum* from the Blood of another Person, it's specifick Gravity appear'd to be 1186.

The Medium between these two last Experiments is 1190, which has since been universally receiv'd for the specifick Gravity of *Serum* of Human Blood, the first Experiment being declar'd by Mr. *Boyle* himself to be less exactly made than the other.

The specifick Gravity of Human Blood was found by Mr. *Boyle*, to be to that of Water, as 1040 to 1000; though on account of difficulties by him mention'd, he was far from being satisfy'd with this Experiment, and recommended the thing to farther tryals.

These

These Experiments however having hitherto past uncontroverted, and it appearing from them, that the specifick Gravity of *Serum* was greater than that of Blood in the proportion of 1190 to 1040, or of 8 to 7 nearly; it was a necessary consequence of this, that the Blood Globules were specifically lighter than the *Serum*, and that in a very great degree, considering the small proportion. that the bulk of the *Crassamentum* was found to bear to that of the *Serum*, from other Experiments.

From this it was not improbably conjectured, that these Globules were thin Vesicles fill'd with an Aereal substance: and this Opinion seem'd to receive a great confirmation, upon it's being observ'd, in viewing the Circulation by a Microscope, that a Blood Globule, in passing through a very narrow Vessel, would change its shape from a Globular to an Oval Form, and would recover it's former Figure, as soon as it was got thro' the narrow Passage; which appearance seem'd to be naturally accounted for from the Elasticity of the included *Aura*.

Upon this conjecture have been built a great many Solutions of the Phænomena observable in the Animal Oeconomy, and the disorders of it; particularly a late ingenious account of Muscular Motion. It is not my business at present to examine any of these, nor is it my design to cast any reflection upon their Authors, who were led into this mistake by the natural consequence of a matter of Fact, for the truth of which they had so great an Authority, as that of the excellent Person above-mentioned. But I hope, I shall easily be pardon'd for enquiring into the soundness of the Foundation, when the Superstructure erected thereupon is so considerable; and the following Experiments, however trivial in themselves, will not appear unworthy the

the consideration of the *Royal Society*, if it be found, that they may prevent us from running into Errors of the greatest consequence.

*Exp. I.* I have several times cut off a small part of the *Craffamentum*, when by its adhesion to the sides of the Porringer it has seem'd to swim upon the Surface of the *Serum*, and have put it into another Vessel fill'd with *Serum*: upon which it has immediately sunk to the Bottom.

*Exp. II.* When the *Coagulum* has been buoy'd up in the *Serum* by the bubbles of Air adhering to its Surface, I have separated a small part of it, where those Bubbles have been thickest, and put it into a Glass of *Serum*, in which it has swom, as before. Then setting the Glass upon the Air-Pump, those Bubbles burst after one another, as the Receiver was exhausting, and the Air being again let into the Receiver, the lump of *Craffamentum* sunk to the bottom of the Glass.

*Exp. III.* I have often placed a drop of *Serum* upon a clean Glass before a Microscope, in which I had dissolv'd a very small quantity of Blood, and observ'd, that when the Glass was held in a perpendicular Posture, the Blood-Globules subsided to the bottom of the Drop; and inverting the Glass, the Globules again descended thro' the *Serum* to the Bottom. I had the same success with a small quantity of *Serum* and Blood in a Capillary Tube. And the same thing has been long since observ'd by the famous Mr. *Leeuwenhoek*.

These Experiments undeniably demonstrate, that the *Craffamentum*, or globular part of the Blood, is specifically heavier than the *Serum*; and consequently it is by no means probable, that the Blood Globules are Vesicles fill'd with Air, or any other Fluid lighter than *Serum*. And that they are not fill'd with any sort of



Elastick Fluid, will appear from the following Experiment.

*Exp. IV.* In a small quantity of *Serum* of Human Blood, I dissolv'd so much Blood, as that the Globules might not lye too thick together, to hinder their being seen distinctly. Then having lodged a small drop of this Liquor on the inside of a thin Glass Tube, I fitted the Tube on to the Air-Pump, and placed a Microscope by it, so that I could see the Blood-Globules through the Tube. This being done, I caus'd the Tube to be exhausted, keeping my Eye upon the Globules all the time, in order to observe whether they dilated themselves, as the Air was withdrawn; but could not perceive the least alteration, they appearing exactly of the same bigness in the *Vacuum*, as they had done before. Whereas if they had been fill'd with an Elastick Fluid, they would either have burst, or have been dilated to at least 70 or 80 times their former Magnitude. The Stop-cock being afterwards turn'd, and the Air suffer'd to re-enter the Tube, the Blood-Globules still retain'd the same bigness, as in *Vacuo*.

To this it will perhaps be objected, that a learned Member of this Society, in a Book lately publish'd, has asserted the direct contrary to what I here affirm, and has assur'd us, that the Blood-Globules in an exhausted Receiver, instantly swell, and dilate themselves so, as to become incredibly large. But as that Gentleman does not tell us, upon what Experiment this assertion is grounded, it may not be unreasonable to suppose, that he was misled by the common Hypothesis, which he there maintains, of the Blood-Globules being fill'd with Air, and by what he has heard or seen of the bubbles of Air, which arise from Blood in the Air Pump in the same manner as from other Liquors, and which not easily breaking out from so viscid a Fluid, occasion  
the

the appearance he mentions. However this may be to prevent any dispute, and avoid the coming to *Utri creditis, Quirites?* I shall offer a Testimony, that every body will be satisfy'd with, namely that of the learned and ingenious Mr. *Machin*, Professor of *Astronomy* in *Gresham Colledge*, and one of our Secretaries, who having honour'd me with his Company at a repetition of this Experiment, in order to be witness to the Event, was fully satisfied upon repeated tryals, that there was no perceivable difference between the Magnitude of the Blood Globules in the Air, and in *Vacuo*. Upon this occasion the two first Experiments were likewise repeated in his presence, with the same Success, as above related.

Though what has been already said is a sufficient proof of the Opinion above-mention'd, yet however to prevent the Objections, which may arise for want of Experiments made in the same manner with Mr. *Boyle's*, as well as for the satisfaction of the Curious, who may be desirous to know the true Specifick Gravities of *Serum* and Blood, I shall proceed to demonstrate the same thing by Hydrostatical Experiments.

*Exp. V. Novemb. 13. 1713.* Having suffer'd a quantity of my own Blood to stand about 24 Hours in the Porringer, and then drawing off the *Serum* carefully with a small *Siphon* into a convenient Glafs, I found by the Hydrostatical Balance it's Specifick Gravity to be to that of Water, as 1029,8 to 1000.

*Exp. VI. Feb. 21. 1716-7.* I examin'd the *Serum* from the Blood of another Person in the same manner and found it's Specifick Gravity to be 1028,6.

*Exp. VII. VIII. and IX. April 8th, 1717.* I obtain'd three several quantities of *Serum* from the Blood of different Persons. The first of these was of a deep

Colour, inclining something to red, and a little Turbid. It's Specifick Gravity was 1029, 7.

The second was likewise a little Turbid, and of a pale whitish Colour. The Specifick Gravity of this was 1030, 2.

The third quantity of *Serum* was perfectly clear, and of the colour of Canary. It's Specifick Gravity was found to be 1030.

Though these five several Experiments were all carefully made, and with a Balance whose accuracy I was well assur'd of, yet for farther Evidence, I thought it proper to make that which follows, after another manner.

*Exp. X. Jan. 15th. 1718.9.* I drew off all the *Serum* from five or six several Porringers, containing the Blood of different Persons. This I found to be a little tinged with Blood, which was occasion'd by my being oblig'd to draw it off pretty near to the bottom of the Porringers, in order to obtain a quantity sufficient for my purpose. For this reason I suffer'd it to stand about two Days, in which time the Globular part of the Blood was entirely precipitated to the Bottom, and the *Serum* was become perfectly fine and transparent. I then drew it off with a *Siphon* into a Glass Vial with a narrow Neck, which I fill'd to a certain mark made in the Neck for that purpose. This done, I plac'd my Vial in a nice pair of Scales, in which I had a counterpoise for the weight of the Vial, and found that quantity of *Serum* to weigh 2284½ Grains.

Then pouring out the *Serum*, I fill'd the Vial with common Water to the same mark, and found the weight of the Water to be 2219 Grains.

From which it follows, that the Specifick Gravity of this *Serum* was 1029, 4.

*Exp.*

*Exp. XI. July 14. 1719.* I procur'd a quantity of Blood taken from the temporal Artery, from which I drew off the *Serum* the next Day, and weighing it in the same manner found it's Specifick Gravity to be 1028, 8.

These Experiments agree so nearly together, that the little difference between them may very well be attributed to that which is between the *Serum* of different Persons; or to the variations occasion'd by heat and cold in the several Seasons of the Year, in which they were made. So that from them we may safely determine the Specifick Gravity of *Serum* of Human Blood at a Medium to be 1029, 5, or in a round number 1030. From which the greatest Variation in any of these Experiments is little more than one in 1000; whereas the difference between Mr. *Boyle's* Experiments and mine amounts to 160 in 1000.

*Exp. XII. April 6. 1717.* In order to find the Specifick Gravity of Human Blood, which, by reason of it's tenacity, and sudden alterations upon standing, cannot be determin'd by the Hydrostatical Balance; I took a narrow-neck'd Vial, and fill'd it to a Mark, with Blood pour'd immediately out of the Porringer, as soon as the Person was Bled. This I weigh'd, as I had done the *Serum* before, and found it's Specifick Gravity to be 1051.

*Exp. XIII. Aug. 5th. 1717.* Having fill'd the same Vial with the Blood of another Person, running immediately out of the Vein through a Funnel, it's Specifick Gravity was determin'd at 1053.

Suffering this to stand till it was cold, I found the Blood was sunk a small matter below the Mark in the neck of the Vial. This being fill'd up with the Water, which in so small a quantity could make no sensible

ble difference from Blood, I found the Specifick Gravity of cold Blood to be 1055.

*Exp. XIV. Aug. 6th. 1718.* The last Experiment being repeated in the same manner as the Year before, the Specifick Gravity of cold Blood was again found to 1055.

*Exp. XV. July 14th. 1719.* The Arterial Blood, from which the *Serum* was afterwards drawn off for the 11th Experiment, being weigh'd in the same manner, it's Specifick Gravity was 1052, 5.

As this Arterial Blood and it's *Serum*, differ no more in Specifick Gravity from Venal Blood and *Serum*, than the several Portions of these do from one another, it's plain, that the difference in this respect between Arterial and Venal Blood is wholly inconsiderable. The Animal Oeconomy indeed teaches us, that the *Serous* Liquor is perpetually drawing off from the Arterial Blood by the several Secretions, but as the quantity separated in one Circulation is very small, the Blood must arrive in the Veins nearly of the same density, as when it runs through the Arteries.

In the 13th Experiment we observ'd, that the Blood alter'd it's Specifick Gravity upon cooling from 1053 to 1055; from which we may infer, that if the Blood made use of in the 12th Experiment had been suffered to stand till it was cold, it's Specifick Gravity would have been 1053; wherefore, taking a Medium between the four last Experiments, we may allow the Specifick Gravity of cold Human Blood to be 1054.

The difference of 14 Parts in a 1000, between this and the Specifick Gravity determined by Mr. *Boyle*, is easily accounted for, if we consider, that that Gentleman did not make use of a Vessel with a narrow Neck, as plainly appears from the circumstances mentioned

tioned in his Experiment; and consequently a small error in the height of the Liquor would make a considerable alteration in the Specifick Gravity.

Since therefore the Specifick Gravity of Human Blood is 1054, and that of its *Serum* 1030, it is plain, that Blood is heavier than *Serum* by about one part in 43. From which it manifestly follows, that the Globular part of the Blood is specifically heavier than the *Serum*, since the Globular part being separated from the Blood leaves the remainder, or the *Serum*, specifically lighter than the intire Mass.

But in order to determine the exact Specifick Gravity of the Blood Globules, it is first necessary to know the Proportion, which the whole quantity of the *Crassamentum* contained in Blood bears to the *Serum*. To this end Mr. Boyle has given us two several Observations of the weights of the *Crassamentum* and *Serum*, after they have separated one from another in the Porringer. But besides the difficulty of making this Experiment with any tolerable exactness, it is to be consider'd, that there is a great deal of *Serum* contain'd in the interstices of the Globules, that compose the *Crassamentum*.

This difficulty however is in some measure answer'd by two other Experiments, which Mr. Boyle made for this purpose, after the following manner. He put a quantity of the *Crassamentum* already separated from the *Serum*, into an Alembick, and distill'd off the remaining *Serum* to dryness, but without drawing off the Oil, or Volatile Salt; after which he weigh'd the distill'd Liquor, and the dry Mass left behind.

By comparing these Experiments with the two former, it will be found that the entire weight of *Serum* contain'd in Blood is nearly  $\frac{2}{3}$  of the whole, and consequently

consequently the weight of the dry'd *Crassamentum* is only two fifteenths of the Blood.

But for farther satisfaction, an Analysis was made at my desire with a large quantity of Blood, amounting to four Pounds fourteen Ounces, by that ingenious and skilfull Chymist, Mr. *John Brown*.

From this was obtain'd, with a very gentle heat, two Pounds, fourteen Ounces, and six Drachms of a Phlegmatick Liquor, that had scarce any thing of the foetid Scent, which is usual in the distillation of Animal Substances; and its Specifick Gravity was nearly the same with that of common Water, being but 1000,8. This being mixt with a strong solution of Alum, scarce afforded any *Coagulum*; but exhibited a considerable one upon mixture with a solution of *Roman Vitriol*.

The distillation being continued with the same Heat, we had seven Ounces more of Phlegm considerably impregnated with Volatile Salt, as was manifest from the Smell. The Specifick Gravity of this was 1007, and having mix'd it with *Tinctura Martis optima*, Solution of Alum, and of *Roman Vitriol*, a large *Coagulum* was precipitated. In distilling these there was lost by Evaporation, two Ounces and two Drachms.

The third portion of Liquor, being rais'd with a stronger Fire, amounted to seven Ounces six Drachms: This was reddish, and turbid, and so strongly charg'd with Volatile Salts, that it might very well deserve the name of Spirit. Its Specifick Gravity was 1080,1.

Besides these we had seven Drachms of Volatile Salt, an ounce of Oil, and eight Ounces four Drachms of *Caput Mortuum*, which still retain'd some small remainder of the Oil, as was manifest from its taking Fire at the flame of a Candle. In this latter part of the Operation was lost three Ounces, seven Drachms.

Upon making due allowance for the difference between the Specifick Gravities of the three first Portions of Liquor and that of *Serum*, as likewise for what was lost in the two several parts of the Operation, which we may reasonably conclude to have been of a Specifick Gravity nearly the same with that of the Liquor drawn off, it will be found, that the quantity of *Serum* contain'd in this Mass of Blood was about  $\frac{15}{17}$  of the whole Weight, and consequently that the quantity of *Craſſamentum* was  $\frac{2}{17}$  of the same Weight.

If we calculate therefore upon this Supposition, that the weight of the Globular part of the Blood is  $\frac{2}{17}$  of the whole, we shall find the Specifick Gravity of a Blood Globule to be to that of Water as 1277 to 1000.

If we follow the proportion of  $\frac{2}{15}$ , which results from Mr. Boyle's Experiments, the Specifick Gravity of a Blood Globule will be 1242.

But this computation is in all appearance a great deal too large; for we cannot be assur'd, that our whole quantity of aqueous Liquor was rais'd from the *Serum* of the Blood. On the contrary it is more than probable, that a considerable part of it was afforded by the Blood Globules themselves, especially in the latter part of the Operation, when their texture must of necessity have been broken and dissolv'd by the strong Fire that was made use of. To prove this, we need only consider the condition of the dry'd *Craſſamentum*, after the Phlegm is drawn off, that being now a hard and brittle substance: whereas the Globules in their natural State are soft and yielding. For which reasons it may perhaps be more satisfactory, if we attempt to find the quantity of the Globular part of the Blood after another manner.

It appears therefore from Mr Boyle's Observations, that the quantity of *Serum*, which may be pour'd off



From the *Crassamentum*, is about one half of the whole Mass. The remaining *Crassamentum* consists of the Blood Globules, and a quantity of *Serum* filling up the Interstices between them; which, if the Globules keep their Spherical Form, may easily be found by the principles of common Geometry, to be nearly one half of the bulk of the *Crassamentum*: but if the Globules by their pressure against one another change their Figure, the quantity of *Serum* will be something less.

If this quantity of *Serum* lying between the Blood Globules be added to that pour'd off, it appears, that the *Serum* contain'd in Blood is about  $\frac{3}{4}$  of the whole bulk, and consequently that the Blood Globules make about  $\frac{1}{4}$  of the whole. From which we shall find the Specifick Gravity of the Blood Globules to be to that of Water as 1126 to 1000.

If we suppose the Blood Globules to make  $\frac{1}{6}$ ,  $\frac{1}{5}$ ,  $\frac{1}{4}$ , or  $\frac{1}{3}$  of the whole bulk, their Specifick Gravity will be respectively 1174, 1150, 1102, or 1078. So that upon any of these Suppositions, the Specifick Gravity of the Blood Globules will be considerably greater than that of the *Serum*, and consequently they cannot be suppos'd to be Vesicles fill'd with an Aereal Substance.

It will therefore perhaps be askt, What do they really consist of?

In order to come to a Solution of this Question, it may be proper to take notice,

That Blood is compos'd of Phlegm, Oil, Volatile and fixt Salts, and Earth. For as to the Spirit, we look upon it with Mr. Boyle, to consist of the Phlegm and Volatile Salt united together.

That the *Serum*, upon a Chymical Analysis, exhibits a great deal of the first of these, and the others in a very small quantity.

That

That on the contrary the *Craffamentum* yields much less Phlegm, but the other Principles much more copiously than the *Serum*.

From which *Data*, I think, we may safely conclude, that the *Craffamentum*, or Globular part of the Blood, consists of some Phlegm united with the Oil and Salts, and a small quantity of Earth.

But what is the exact proportion of these several Principles to one another; what alterations are produced in the Body by a change of this proportion; how, and in what part these Globules are form'd; by what means they preserve their Figure, without dissolving in the *Serum*, or uniting with one another; what variations are made in their Specifick Gravities by Heat and Cold; and what are the effects of those Variations, are Questions not very easy to be solv'd, and yet of so much importance to the Animal Oeconomy, that it were greatly to be wisht, we had a number of *Data* sufficient to determine them.

*P. S.* Since this Paper was sent to the Press, I made the following Experiments, which serving to confirm the Method last made use of, for finding the Specifick Gravity of the Blood Globules, it may not be improper to relate them.

*August 6. 1719.* I took a lump of the *Craffamentum*, and wash'd it gently in fair Water, to free it from the loose Globules, which precipitating out of the *Serum*, after the *Coagulum* is form'd, do not unite into one Body with it. This done, I laid it on a spongy brown Paper, in order to drain off the superfluous Moisture. After which, weighing it first in Air, and then in Water, I found its Specifick Gravity to be  $1083\frac{1}{2}$ .

Another lump of the same *Craffamentum* being weigh'd in the same manner, its Specifick Gravity was 1082.9.

Sept. 18. 1719. I found the Specifick Gravity of another piece of *Craffamentum* to be 1082.1.

A second piece from the Blood of a different Person gave me 1086.1.

A third from the same Person gave 1086.6.

From this it follows that the Specifick Gravity of the Blood Globules is at least 1084, which is the *Medium* between these five Experiments.

But if we allow one half of the bulk of the *Craffamentum* to consist of *Serum*, filling up the Spaces between the Blood Globules, we shall find their Specifick Gravity to be 1138.

From this we must make a small abatement, because some part of the *Serum* must have been squeez'd out from between the Globules, by their yielding to one anothers Pressure, when the lump of *Craffamentum* lay upon the Paper: and this will reduce their Specifick Gravity sufficiently near to 1126, as we had before determin'd it.

IV. *An Account of the Sunk Island in Humber, some Years since recover'd from the Sea. Being an Extract of a Letter Communicated to the Royal Society by John Chamberlayne, Esq;*  
R. S. S.

THIS Island goes by the name of the *Sunk Island*, so called I suppose from the sinking Marsh Ground about it. As for its Original one may make pretty sure Conjectures of that I believe, because 'tis yet within

in the memory of Man, since it began to raise its Head above the Ocean, there being several old People here alive, who can remember when there appeared nothing of it but a vast and barren Sand; and that only at Low-Water too, when for the space of a few Hours it shewed its Head, and then was buried again till the next Tides Retreat: thus successively it liv'd and died until the Year 1666, when it began to maintain its ground against the insult of the Waves; about which time it began to be rescued wholly from future danger, by the Care and Industry of Colonel *Gilby*, who having, as I am inform'd, a Lease or Gift of it from the Crown, did raise Banks about the rising Grounds of it, and so defending it from the Encroachments of the Water, it became Firm and Solid; and in a short time afforded good Pasturage for Sheep and other Cattel. The Expences at first to improve it to what it is, must needs have been very considerable; it being encompass'd with high Banks, and deep Canals for receiving and discharging the Liquid Element, which every now and then notwithstanding threatens to repossess it self of its ancient Hereditament, but hitherto in vain; for I now acquaint you of its present Safety.

This Island is now about 9 Miles in Circumference, within the Banks, which seem to render it impregnable against all future attacks of the Sea, and is of a very fat and fertile Soil, affords good Grass, Corn and Hay, and is replenish'd with numerous flocks of Sheep, which are of a larger Size and finer Wool than those in *Hildernefs*, from which it is divided by about two Miles in Water; and from *Lincolnshire* by about four. It is stor'd with vast numbers of Rabbits, that seem innumerable, they appearing through all Parts in prodigious Swarms; their Skins are counted the finest in *England*, of a dark Mouse Colour, Shagg'd, and soft as Silk.

There

There are also Cows and Horses feeding constantly in the Place, with great plenty of Wild Fowl.

The Inhabitants are not so numerous, there being only three Families that live constantly upon the Place; however they are never too solitary, there being abundance of Workmen and Labourers that continually resort thither, sometimes I am told to the number of a Hundred and upwards, for the repairing of the Banks, &c.

The Yearly Income of the Proprietor Mr. Gilby, amounts to about 800*l.* and pays the King's Taxes to those who Collect for the *East-Riding*, and is usually uplifted by those of the Liberty and Township of *Ottringham*, from the Marshes of which there is a Passage over the Sands to the *Sunk* at Low-water. But this Custom of paying the King's Cess to them, proceeds only from the conveniency, not Necessity; for it never belong'd to that or any other Parish, so that I cannot resolve you in what Diocese this Island lyes, unless it had been united to some neighbouring Parish, or converted to one of it self; which if effected, the Tyth of Lambs, Wool and Rabbits, &c. would make up a handsome Benefice. It lyes nearer indeed to the Diocese of *Tork*, by at least two Miles, than to that of *Lincoln*, being two Miles South of *Holderness*, in the River *Humber*, and four Miles North of *Lincolnshire*, &c.

*Welwick, April 14.*

1717.

V. A

V. *A Way for Myopes to use Telescopes without Eye-Glasses, an Object-Glass alone becoming as useful to them, and sometimes more than a Combination of Glasses. Communicated to the Royal-Society, by the Reverend J. T. Desaguliers, LL. D. and F. R. S.*

*Lemma I.*

**W**Hat is requir'd of a Telescope is to give large, and distinct Vision; that is, to make the Object (as in *Galileo's Telescope*) or its Image (as in the Telescopes made up of Convex *Lentes*) appear under a great Angle, and to have all the Rays of those Pencils that enter the Eye, meet in a point upon the *Retina* of the Eye, on their respective Axes.

The first Figure represents the Combination of two Convex *Lentes* for the Astronomical or inverting Telescope; where the above-mentioned Requisites are obtain'd. *AB* is the Object suppos'd at a vast distance from the Objective *Lens LL*, so that Rays coming from the extremity *A* of the Object, will fall upon the *Lens LL*, in the same manner as if they were parallel to their Axis *AX*; and after passing the Glass unite at *a*, where they project the Image of the Point *A*; from whence diverging, they fall on the Eye-Glass *ll*, and having pass'd through it, go on parallel to each other, and enter the *Cornea* of a common Eye *E*, which unites those parallel Rays upon its *Retina RRR* at *a*, where the Image of *a* is projected: The same may be said of the Rays that come from *B*, and after their

their several refractions through the two Glasses and the Coats and Humours of the Eye, meet upon the *Retina* at  $\beta$ , where they project the distinct Image of the Point  $b$ . The Rays that come from all the Points of the Object  $AB$  being affected after the same manner, give a distinct Image of those Points upon the *Retina*, and therefore the Object does appear distinct.

The Object will also appear magnified in the same proportion as the Angle  $\angle C l =$  to  $\angle M a$  (under which its Image is seen,) is greater than the Angle  $\angle A C B$  under which the Object  $AB$  would be seen by the naked Eye; as is more at large demonstrated by Dioptrical Writers.

*Lemma 2.*

If parallel Rays fall upon the *Cornea* of a *Myops*, or short-sighted Person, they will unite in the Eye, before they come to the *Retina*, the farther from it the more Convex the Eye is; but if the Rays which fall upon the *Cornea* diverge in proportion to the too great Convexity of the Eye, as from  $D$ , such Rays will be so refracted by the Coats and Humours of the Eye as to meet in one point upon the *Retina*  $RR$ , see *Fig. 2* and *3*. Where I have in the Scheme neglected the Refraction of the Rays passing out of the *CrySTALLINE*  $K$  into the *Vitreous* Humour  $V$ , as I do in the other Cases.

This *Lemma* is also demonstrated by Dioptrical Writers.

*Lemma 3.*

If two Pencils of Rays (in each whereof all the Rays are parallel to the Axis, as  $a C$ ) fall upon different Parts of the *Cornea*, at the greatest distance from one another that can be allow'd for those Rays to enter the Pupil  $PP$ , their *Axes* will, after entering the

*Aqueous*

*Aqueous Humour*, converge, and meet either in the *Vitreous*, or *Cryſtalline Humour*, according to the *Convexity* of the *Cornea* thro' which they paſs'd, and diverge again before they come to the *Retina*; the *Rays* of each *Pencil* converging upon their reſpective *Axes*, to the place where the ſaid *Axes* croſs one another, *Fig. 4.*

*Demonſtration.*

The *Axes*  $aCa$ ,  $\alpha C\alpha$ , falling obliquely upon the *Cornea* at  $C, C$ , and entring from *Air* into the *Aqueous Humour*, will be refracted towards the Perpendicular to  $K$ : where ſtriking more directly upon the *Cryſtalline*, they will go on to  $\alpha, a$ , upon the *Retina*  $RRRR$ , decuſſating at  $V$  within the *Vitreous Humour*. The other *Rays*  $r, r$ ;  $p, p$ , after their Refraction in the *Aqueous Humour*, fall more obliquely on the *Cryſtalline*, and therefore are refracted again ſo as to meet at  $V$ , where the *Axes* alſo meet, and thence go on to the *Retina*  $RRRR$ , *Fig. 4.*

*Lemma 4.*

But if the *Axes* of the above-mention'd *Pencils* are Parallel, the *Rays* that accompany them diverging from a Point ſo near the *Eye*, that the divergence may be proportionable to the too great *Convexity* of the *Eye*; then only the *Axes* will meet in the *Eye* before they come to the *Retina* (by *Lemma 3.*) but the other *Rays* will not unite upon their reſpective *Axes*, till they come to the *Retina*, (by *Lemma 2.*)

*Propoſition.*

I ſuppoſe the *Eye* of the *Myops* ſo *Convex* that he can ſee no farther than a common *Eye*, with the *Eye-Glaſs* of a *Telescope* before it: then the *Eye* of the



*Myops* being in the place of the Eye-Glass, will receive the Rays diverging from the several points of the Image (projected by the Object-Glass in its *Focus*,) in such manner, that they will after their several refractions meet in respective Points on the *Retina*; and the Axes of the Pencils which come from the extremities of the Object, will, in the Eye, make the Angle  $BVA =$  to  $bca$ , under which the Image  $ab$  is seen, by *Lemma 4*. The *Cornea* and *Aqueous Humour* here supply the place of the Eye-Glass, and the *CrySTALLINE* and *Vitreous Humours* that of a common Eye, See the 5th *Fig.* wherein *R* is the *Retina*, *V* the *Vitreous Humour*, and *KK* the *CrySTALLINE Humour*; and the Image  $ba$  is suppos'd to be brought down from the *first Fig.* which represents the *Astronomick Telescope*: the too great Convexity of the Eye here being in the place of an Eye-Glass.

An Objection may be made to this, *viz.* that *PP* the Pupil of the Eye being small, will take in but a very little Image, or a small part of the Object: But then if the Eye be mov'd successively, to all the parts of the Space where the Eye-Glass was, it can take any part of the Object; and if the Object-Glass be large, which may more easily be made than a large Eye-Glass, and the Tube a Foot wide or wider, as much may successively be taken in, as if an Eye-Glass might be had of a Foot Diameter. A little practice may make any *Myops* so ready, as to keep an Object when once found, though the place where he stands be shaken. It would not be amiss to hold a *Lens* in one's Hand (for an Eye-Glass) to find the Object at first, till custom has made it easy without it: when once the Object is found, it may be easily kept.

An Eye more short-sighted than I have suppos'd, will perform the Office of a more Convex Eye-Glass, being

being brought nearer to the distinct Base of the Object Glass; and an Eye less Convex, the office of a less Convex Eye-Glass: but with this difference, that the more Convex the Eye is, the easier may any part of the Object be found, and the larger and more lucid it will appear.

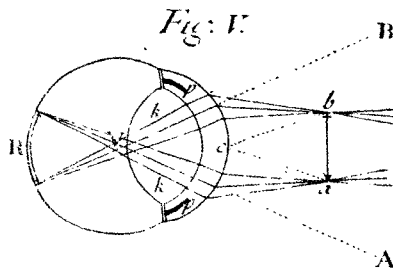
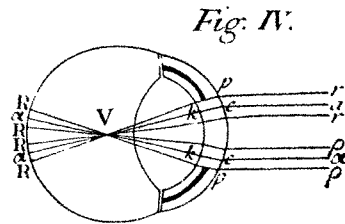
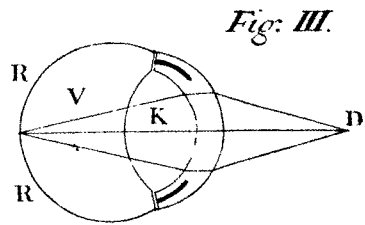
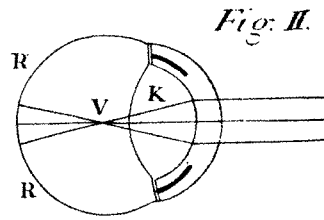
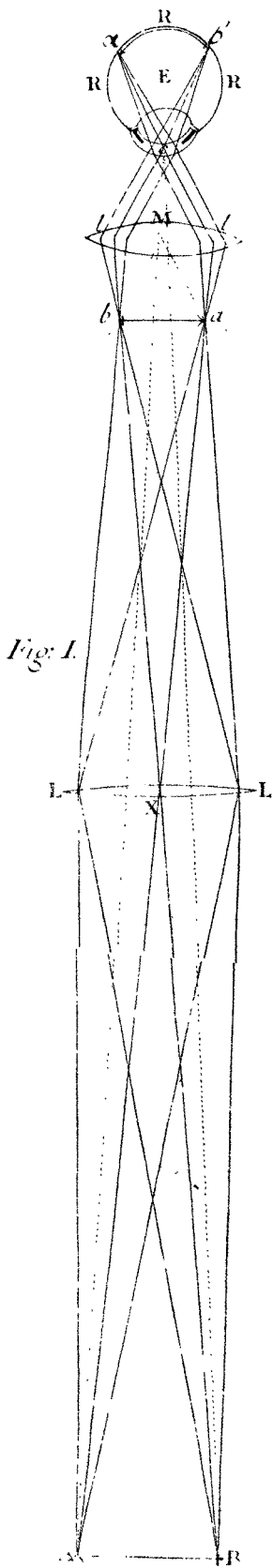
I have seen *Saturn's* Ring very plain with an Object-Glass of little more than six Foot *Radius*, without an Eye-Glass.

I have also found out a way for the *Presbyta* to make use of an Object-Glass, by placing their Eye nearer the *Lens* than its *Focus*, by so much as their Eye is flatter than a common Eye, so as to make (as it were) the Telescope of *Galileo*; the flat Eye serving as a common Eye arm'd with a Concave *Lens*. I have so fixed the Telescope, as to make a *Presbyta* read at a great distance a small Print. The truth of this may be easily demonstrated, if it be requir'd.

If this Experiment be made at Sea with a very large Tube, big enough to put in the Head and move it about, and the Object-Glass be also large, it may not perhaps be difficult to observe the Eclipses of the *Satellites* of *Jupiter*, which I would recommend to the Consideration of those that would try for the Longitude by such like Observations.

VI. *New and accurate Tables for the ready Computing of the Eclipses of the first Satellite of Jupiter, by Addition only.* By the Reverend Mr James Pound, R. S. S.

**I**N Numb. 214. of these *Transactions*, for the Months of *Novem* and *Decem.* 1694. we exhibited an Epitomy of Mr. *Cassini's* curious Tables then newly published.



lished. for computing the Eclipses of the *first Satellite* of *Jupiter*, without the help of any other Numbers. The ease of this *Calculus* gave great satisfaction to those that delight in Telescope observations; and has been of good use to encourage Astronomers to ascertain the Geographical Longitudes of many places, by help of these Eclipses; whose frequency seems to afford us the properest means for that purpose.

But it being now 26 Years since those Tables were published, length of Time has discovered that this *Satellites* motion is a small matter swifter than M. *Cassini* had supposed it; and the Reverend Mr. *Pound* being provided with all the Qualifications requisite for such a Work, has of late apply'd himself to rectify by frequent Observation what he found amiss in the afore-said *Calculus*; and withal has put it into another Form yet much more easy and compendious, by bringing what M. *Cassini* had given us in odd Numbers, to the Millefimals of a Circle, both as to *Numb. I.* which he calls *Numb. A.* being the mean Anomalie of *Jupiter* in such parts; as also to *Numb. II.* or our *Numb. B.* which is the distance of the mean place of *Jupiter*, from the true place of the *Sun*, and which with the addition of the Equation of *Numb. B.* gives the true angle of *Commotation* in the same Millefimals of a Circle. And having deducted from the *Epoches* the greatest Equations both of *Numb. A.* and *B.* he restores them by adding as much to the Equations themselves, by which means they all become Affirmative, so that the whole computation is performed by Addition only.

The Reader is supposed to be acquainted with the Method of M. *Cassini's Calculus*, which is at large explain'd in the afore-said *Transaction*, *Num. 214.* For which reason this shorter Description may suffice at present.

*Epochæ Conjunctionum Primi Satellitis Cum Jove.*

| An. Jul.<br>Curr. | Conjun&. |    |    |    | Num.<br>A. | Num.<br>B. | An. Jul.<br>Curr. | Conjun&. |    |    |    | Num.<br>A. | Num.<br>B. |
|-------------------|----------|----|----|----|------------|------------|-------------------|----------|----|----|----|------------|------------|
|                   | D.       | H. |    |    |            |            |                   | D.       | H. |    |    |            |            |
| 1719              | 1        | 6  | 11 | 13 | 872        | 396        | 1749              | 0        | 11 | 9  | 34 | 400        | 866        |
| 1720              | 0        | 20 | 22 | 40 | 956        | 310        | 1750              | 0        | 1  | 21 | 1  | 485        | 780        |
| 21                | 1        | 5  | 2  | 44 | 40         | 229        | 51                | 1        | 10 | 1  | 5  | 569        | 698        |
| 22                | 0        | 19 | 14 | 11 | 125        | 143        | 52                | 1        | 0  | 12 | 33 | 653        | 612        |
| 23                | 0        | 9  | 25 | 38 | 209        | 57         | 53                | 1        | 8  | 52 | 37 | 738        | 531        |
| 1724              | 1        | 18 | 5  | 42 | 293        | 371        | 1754              | 0        | 23 | 4  | 4  | 822        | 445        |
| 1725              | 0        | 8  | 17 | 10 | 377        | 889        | 1755              | 0        | 13 | 15 | 32 | 906        | 359        |
| 26                | 1        | 16 | 57 | 13 | 462        | 808        | 56                | 0        | 3  | 27 | 0  | 990        | 273        |
| 27                | 1        | 7  | 8  | 41 | 546        | 722        | 57                | 0        | 12 | 7  | 3  | 75         | 191        |
| 28                | 0        | 21 | 20 | 8  | 630        | 636        | 58                | 0        | 2  | 18 | 30 | 159        | 110        |
| 3729              | 1        | 6  | 0  | 12 | 715        | 554        | 1759              | 1        | 10 | 58 | 34 | 243        | 24         |
| 1730              | 0        | 20 | 11 | 39 | 799        | 468        | 1760              | 1        | 1  | 10 | 1  | 328        | 938        |
| 31                | 0        | 10 | 23 | 7  | 883        | 382        | 61                | 1        | 9  | 50 | 35 | 412        | 856        |
| 32                | 0        | 0  | 34 | 34 | 567        | 296        | 62                | 1        | 0  | 1  | 2  | 496        | 770        |
| 33                | 0        | 9  | 14 | 38 | 52         | 215        | 63                | 0        | 14 | 13 | 0  | 580        | 684        |
| 1734              | 1        | 17 | 54 | 41 | 136        | 133        | 1764              | 0        | 4  | 24 | 27 | 665        | 598        |
| 1735              | 1        | 8  | 6  | 9  | 220        | 47         | 1765              | 0        | 13 | 4  | 31 | 749        | 517        |
| 36                | 0        | 22 | 17 | 36 | 305        | 961        | 66                | 0        | 3  | 15 | 58 | 833        | 431        |
| 27                | 1        | 6  | 57 | 40 | 389        | 880        | 67                | 1        | 11 | 56 | 2  | 918        | 349        |
| 38                | 0        | 21 | 9  | 7  | 473        | 794        | 68                | 1        | 2  | 7  | 29 | 2          | 163        |
| 1739              | 0        | 11 | 20 | 35 | 557        | 708        | 1769              | 1        | 10 | 47 | 33 | 86         | 182        |
| 1740              | 0        | 1  | 32 | 2  | 642        | 622        | 1770              | 1        | 0  | 59 | 0  | 171        | 96         |
| 41                | 0        | 10 | 12 | 6  | 726        | 540        | 71                | 0        | 15 | 10 | 28 | 255        | 10         |
| 42                | 0        | 0  | 23 | 33 | 810        | 454        | 72                | 0        | 5  | 21 | 56 | 339        | 924        |
| 43                | 1        | 9  | 3  | 37 | 895        | 373        | 73                | 0        | 14 | 2  | 0  | 423        | 842        |
| 1744              | 0        | 23 | 15 | 4  | 979        | 287        | 1774              | 0        | 4  | 13 | 27 | 508        | 761        |
| 1745              | 1        | 7  | 55 | 8  | 63         | 205        | 1775              | 1        | 12 | 53 | 31 | 592        | 675        |
| 46                | 0        | 22 | 6  | 35 | 148        | 119        | 76                | 1        | 3  | 4  | 58 | 676        | 589        |
| 47                | 0        | 12 | 18 | 3  | 232        | 33         | 77                | 1        | 11 | 45 | 1  | 761        | 507        |
| 48                | 0        | 2  | 29 | 30 | 316        | 947        | 78                | 1        | 1  | 56 | 28 | 845        | 421        |
| 1749              | 0        | 11 | 9  | 34 | 400        | 866        | 1779              | 0        | 16 | 7  | 56 | 929        | 335        |

*Revoluciones Primi Satellitis Jovis in mensibus.*

| <i>Januarii.</i> |    |    |    | N. | Nu. | <i>Februarii.</i> |    |    |    | N. | Nu. |
|------------------|----|----|----|----|-----|-------------------|----|----|----|----|-----|
| D. h.            |    |    |    | A. | B.  | D. h.             |    |    |    | A. | B.  |
| 1                | 18 | 28 | 36 | 0  | 5   | 15                | 0  | 23 | 35 | 11 | 118 |
| 3                | 12 | 57 | 12 | 1  | 9   | 16                | 18 | 52 | 11 | 11 | 123 |
| 5                | 7  | 25 | 48 | 1  | 14  | 18                | 13 | 20 | 47 | 11 | 128 |
| 7                | 1  | 54 | 24 | 2  | 18  | 20                | 7  | 49 | 23 | 12 | 132 |
| 8                | 20 | 23 | 0  | 2  | 23  | 22                | 2  | 17 | 59 | 12 | 137 |
| 10               | 14 | 51 | 36 | 2  | 27  | 23                | 20 | 46 | 35 | 13 | 141 |
| 12               | 9  | 20 | 12 | 3  | 32  | 25                | 15 | 15 | 11 | 13 | 146 |
| 14               | 3  | 48 | 48 | 3  | 37  | 27                | 9  | 43 | 47 | 13 | 150 |
| 15               | 22 | 17 | 24 | 4  | 41  | <i>Martii.</i>    |    |    |    |    |     |
| 17               | 16 | 46 | 0  | 4  | 46  | 1                 | 4  | 12 | 23 | 14 | 155 |
| 19               | 11 | 14 | 36 | 4  | 51  | 2                 | 22 | 40 | 59 | 14 | 159 |
| 21               | 5  | 43 | 12 | 5  | 55  | 4                 | 17 | 9  | 35 | 15 | 164 |
| 23               | 0  | 11 | 47 | 5  | 60  | 6                 | 11 | 38 | 10 | 15 | 168 |
| 24               | 18 | 40 | 23 | 6  | 64  | 8                 | 6  | 6  | 46 | 16 | 173 |
| 26               | 13 | 8  | 59 | 6  | 69  | 10                | 0  | 35 | 22 | 16 | 177 |
| 28               | 7  | 37 | 35 | 7  | 73  | 11                | 19 | 3  | 58 | 16 | 182 |
| 30               | 2  | 6  | 11 | 7  | 78  | 13                | 13 | 32 | 34 | 17 | 186 |
| 31               | 20 | 34 | 47 | 7  | 82  | 15                | 8  | 1  | 10 | 17 | 190 |
| <i>Februarii</i> |    |    |    |    |     | 17                | 2  | 29 | 46 | 18 | 195 |
| 0                | 20 | 34 | 47 | 7  | 82  | 18                | 20 | 58 | 22 | 18 | 199 |
| 2                | 15 | 3  | 23 | 8  | 87  | 20                | 15 | 26 | 58 | 18 | 204 |
| 4                | 9  | 31 | 59 | 8  | 92  | 22                | 9  | 55 | 34 | 19 | 208 |
| 6                | 4  | 0  | 35 | 9  | 96  | 24                | 4  | 24 | 10 | 19 | 213 |
| 7                | 22 | 29 | 11 | 9  | 101 | 25                | 22 | 52 | 46 | 20 | 217 |
| 9                | 16 | 57 | 47 | 9  | 105 | 27                | 17 | 21 | 22 | 20 | 221 |
| 11               | 11 | 26 | 23 | 10 | 110 | 29                | 11 | 49 | 58 | 20 | 225 |
| 13               | 5  | 54 | 59 | 10 | 114 | 31                | 6  | 18 | 34 | 21 | 230 |

*Aprilis.*

*Revolutiones Primi Satellitis Jovis in mensibus.*

| <i>Aprilis.</i> |    |    |    | N. | Nu. | <i>Maii.</i> |    |    |    | N. | Nu. |  |  |
|-----------------|----|----|----|----|-----|--------------|----|----|----|----|-----|--|--|
| D. h. , "       |    |    |    | A. | B.  | D. h. , "    |    |    |    | A. | B.  |  |  |
| 0               | 6  | 8  | 34 | 21 | 230 | 16           | 6  | 42 | 9  | 31 | 343 |  |  |
| 2               | 0  | 47 | 10 | 21 | 235 | 18           | 1  | 10 | 45 | 32 | 348 |  |  |
| 3               | 19 | 15 | 46 | 22 | 239 | 19           | 19 | 39 | 21 | 32 | 352 |  |  |
| 5               | 13 | 44 | 22 | 22 | 244 | 21           | 14 | 7  | 57 | 33 | 356 |  |  |
| 7               | 8  | 12 | 58 | 22 | 248 | 23           | 8  | 36 | 33 | 33 | 361 |  |  |
| 9               | 2  | 41 | 34 | 23 | 252 | 25           | 3  | 5  | 9  | 33 | 365 |  |  |
| 10              | 21 | 10 | 10 | 23 | 257 | 26           | 21 | 33 | 45 | 34 | 369 |  |  |
| 12              | 15 | 38 | 46 | 24 | 261 | 28           | 16 | 2  | 21 | 34 | 373 |  |  |
| 14              | 10 | 7  | 22 | 24 | 265 | 30           | 10 | 30 | 57 | 35 | 378 |  |  |
| 16              | 4  | 35 | 58 | 25 | 270 | <i>Junii</i> |    |    |    |    |     |  |  |
| 17              | 23 | 4  | 33 | 25 | 274 | 0            | 10 | 30 | 57 | 35 | 378 |  |  |
| 19              | 17 | 33 |    | 25 | 279 | 1            | 4  | 59 | 32 | 35 | 382 |  |  |
| 21              | 12 | 1  | 45 | 26 | 283 | 2            | 23 | 28 | 8  | 36 | 386 |  |  |
| 23              | 6  | 30 | 21 | 26 | 287 | 4            | 17 | 56 | 44 | 36 | 391 |  |  |
| 25              | 0  | 58 | 57 | 27 | 292 | 6            | 12 | 25 | 20 | 36 | 395 |  |  |
| 26              | 19 | 27 | 33 | 27 | 296 | 8            | 6  | 53 | 56 | 37 | 399 |  |  |
| 28              | 13 | 56 | 9  | 27 | 300 | 10           | 1  | 22 | 32 | 37 | 403 |  |  |
| 30              | 8  | 24 | 45 | 28 | 304 | 11           | 19 | 51 | 8  | 38 | 408 |  |  |
| <i>Maii.</i>    |    |    |    |    |     | 13           | 14 | 19 | 44 | 38 | 412 |  |  |
| 0               | 8  | 24 | 45 | 28 | 304 | 15           | 8  | 48 | 20 | 38 | 416 |  |  |
| 2               | 2  | 53 | 21 | 28 | 309 | 17           | 3  | 16 | 56 | 39 | 420 |  |  |
| 3               | 21 | 21 | 57 | 29 | 313 | 18           | 21 | 45 | 32 | 39 | 425 |  |  |
| 5               | 15 | 50 | 33 | 29 | 317 | 20           | 16 | 14 | 8  | 40 | 429 |  |  |
| 7               | 10 | 19 | 9  | 29 | 322 | 22           | 10 | 42 | 44 | 40 | 433 |  |  |
| 9               | 4  | 47 | 45 | 30 | 326 | 24           | 5  | 11 | 20 | 40 | 438 |  |  |
| 10              | 23 | 16 | 21 | 30 | 330 | 25           | 23 | 39 | 56 | 41 | 442 |  |  |
| 12              | 17 | 44 | 57 | 31 | 335 | 27           | 18 | 8  | 32 | 41 | 446 |  |  |
| 14              | 12 | 13 | 33 | 31 | 339 | 29           | 12 | 37 | 8  | 42 | 450 |  |  |

*Julii*

( 1026 )

*Revoluciones Primi Satellitis Jovis in m<sup>o</sup> Gbus.*

| <i>Julii.</i>      |    |    |    | N. | Nu. | <i>Augusti.</i>    |    |    |    | N. | Nu. |
|--------------------|----|----|----|----|-----|--------------------|----|----|----|----|-----|
| D. h. <sub>u</sub> |    |    |    | A. | B.  | D. h. <sub>u</sub> |    |    |    | A. | B.  |
| 1                  | 7  | 5  | 44 | 42 | 455 | 16                 | 7  | 29 | 19 | 53 | 567 |
| 3                  | 1  | 34 | 20 | 42 | 459 | 18                 | 1  | 57 | 55 | 53 | 571 |
| 4                  | 20 | 2  | 56 | 43 | 463 | 19                 | 20 | 26 | 31 | 54 | 575 |
| 6                  | 14 | 31 | 32 | 43 | 468 | 21                 | 14 | 55 | 7  | 54 | 580 |
| 8                  | 9  | 0  | 8  | 44 | 472 | 23                 | 9  | 23 | 43 | 54 | 584 |
| 10                 | 3  | 28 | 44 | 44 | 476 | 25                 | 3  | 52 | 18 | 55 | 588 |
| 11                 | 21 | 57 | 20 | 45 | 480 | 26                 | 22 | 20 | 54 | 55 | 593 |
| 13                 | 16 | 25 | 55 | 45 | 485 | 28                 | 16 | 49 | 30 | 56 | 597 |
| 15                 | 10 | 54 | 31 | 45 | 489 | 30                 | 11 | 18 | 6  | 56 | 602 |
| 17                 | 5  | 23 | 7  | 46 | 493 | <i>Septembris.</i> |    |    |    |    |     |
| 18                 | 23 | 51 | 43 | 46 | 498 | 1                  | 5  | 46 | 42 | 56 | 606 |
| 20                 | 18 | 20 | 19 | 47 | 502 | 3                  | 0  | 15 | 18 | 57 | 610 |
| 22                 | 12 | 48 | 55 | 47 | 506 | 4                  | 18 | 43 | 54 | 57 | 615 |
| 24                 | 7  | 17 | 31 | 47 | 510 | 6                  | 13 | 12 | 30 | 58 | 619 |
| 26                 | 1  | 46 | 7  | 48 | 515 | 8                  | 7  | 41 | 6  | 58 | 624 |
| 27                 | 20 | 14 | 43 | 48 | 519 | 10                 | 2  | 9  | 42 | 58 | 628 |
| 29                 | 14 | 43 | 19 | 49 | 523 | 11                 | 20 | 38 | 18 | 59 | 632 |
| 31                 | 9  | 11 | 55 | 49 | 528 | 13                 | 15 | 6  | 54 | 59 | 637 |
| <i>Augusti.</i>    |    |    |    |    |     | 15                 | 9  | 35 | 30 | 60 | 641 |
| 0                  | 9  | 11 | 55 | 49 | 528 | 17                 | 4  | 4  | 6  | 60 | 646 |
| 2                  | 3  | 40 | 31 | 49 | 532 | 18                 | 22 | 32 | 42 | 60 | 650 |
| 3                  | 22 | 9  | 7  | 50 | 536 | 20                 | 17 | 1  | 18 | 61 | 655 |
| 5                  | 16 | 37 | 43 | 50 | 541 | 22                 | 11 | 29 | 54 | 61 | 659 |
| 7                  | 11 | 6  | 19 | 51 | 545 | 24                 | 5  | 58 | 30 | 62 | 663 |
| 9                  | 5  | 34 | 55 | 51 | 549 | 26                 | 0  | 27 | 6  | 62 | 668 |
| 11                 | 0  | 3  | 31 | 51 | 554 | 27                 | 18 | 55 | 42 | 62 | 672 |
| 12                 | 18 | 32 | 7  | 52 | 558 | 29                 | 13 | 24 | 18 | 63 | 677 |
| 14                 | 13 | 0  | 43 | 52 | 562 |                    |    |    |    |    |     |



*Revoluciones Primi Satellitis Jovis in mensibus.*

| Oſtobris.  |    |    |    | N. | Nu. | Novembris. |    |    |    | N. | Nu. |  |  |
|------------|----|----|----|----|-----|------------|----|----|----|----|-----|--|--|
| D. h.      |    |    |    | A. | B.  | D. h.      |    |    |    | A. | B.  |  |  |
| 1          | 7  | 52 | 54 | 63 | 681 | 16         | 8  | 16 | 29 | 74 | 799 |  |  |
| 3          | 2  | 21 | 30 | 64 | 686 | 18         | 2  | 45 | 5  | 74 | 804 |  |  |
| 4          | 20 | 50 | 6  | 64 | 690 | 19         | 21 | 13 | 40 | 75 | 808 |  |  |
| 6          | 15 | 18 | 41 | 65 | 695 | 21         | 15 | 42 | 16 | 75 | 813 |  |  |
| 8          | 9  | 47 | 17 | 65 | 699 | 23         | 10 | 10 | 52 | 76 | 817 |  |  |
| 10         | 4  | 15 | 53 | 65 | 704 | 25         | 4  | 39 | 28 | 76 | 822 |  |  |
| 11         | 22 | 44 | 29 | 66 | 708 | 26         | 23 | 8  | 4  | 76 | 827 |  |  |
| 13         | 17 | 13 | 5  | 66 | 713 | 28         | 17 | 36 | 40 | 77 | 831 |  |  |
| 15         | 11 | 41 | 41 | 67 | 717 | 30         | 12 | 5  | 16 | 77 | 836 |  |  |
| 17         | 6  | 10 | 17 | 67 | 721 |            |    |    |    |    |     |  |  |
| 19         | 0  | 38 | 53 | 67 | 726 | Decembris. |    |    |    |    |     |  |  |
| 20         | 19 | 7  | 29 | 68 | 730 | 0          | 12 | 5  | 16 | 77 | 836 |  |  |
| 22         | 13 | 36 | 5  | 68 | 735 | 2          | 6  | 33 | 52 | 78 | 840 |  |  |
| 24         | 8  | 4  | 41 | 69 | 739 | 4          | 1  | 2  | 28 | 78 | 845 |  |  |
| 26         | 2  | 33 | 17 | 69 | 744 | 5          | 19 | 31 | 4  | 78 | 849 |  |  |
| 27         | 21 | 1  | 53 | 69 | 749 | 7          | 13 | 59 | 40 | 79 | 854 |  |  |
| 29         | 15 | 30 | 29 | 70 | 753 | 9          | 8  | 28 | 16 | 79 | 859 |  |  |
| 31         | 9  | 59 | 5  | 70 | 758 | 11         | 2  | 56 | 52 | 80 | 863 |  |  |
| Novembris. |    |    |    |    |     | 13         | 21 | 25 | 28 | 80 | 868 |  |  |
| 0          | 9  | 59 | 5  | 70 | 758 | 14         | 15 | 54 | 4  | 80 | 873 |  |  |
| 2          | 4  | 27 | 41 | 71 | 762 | 16         | 10 | 22 | 40 | 81 | 877 |  |  |
| 3          | 22 | 56 | 17 | 71 | 767 | 18         | 4  | 51 | 16 | 81 | 882 |  |  |
| 5          | 17 | 24 | 53 | 71 | 772 | 19         | 23 | 19 | 52 | 82 | 886 |  |  |
| 7          | 11 | 53 | 29 | 72 | 776 | 21         | 17 | 48 | 28 | 82 | 891 |  |  |
| 9          | 6  | 22 | 5  | 72 | 781 | 23         | 12 | 17 | 4  | 82 | 897 |  |  |
| 11         | 0  | 50 | 41 | 73 | 785 | 25         | 6  | 45 | 40 | 83 | 900 |  |  |
| 12         | 19 | 19 | 17 | 73 | 790 | 27         | 1  | 14 | 16 | 83 | 905 |  |  |
| 14         | 13 | 47 | 53 | 74 | 794 | 28         | 19 | 42 | 52 | 84 | 909 |  |  |
|            |    |    |    |    |     | 30         | 14 | 11 | 28 | 84 | 914 |  |  |

( 1028 )

*Prima Equationes Conjunctionum Primi Satellitis  
cum Jove.*

| Num.<br>A. | Equat.<br>Conjun.<br>Adde. | Eq.<br>Nu.<br>B. | Num.<br>A. | Equat.<br>Conjun.<br>Adde. | Eq.<br>Nu.<br>B. | Num.<br>A. | Equat.<br>Conjun.<br>Adde. | Eq.<br>Nu.<br>B. | Num.<br>A. | Equat.<br>Conjun.<br>Adde. | Eq.<br>Nu.<br>B. |
|------------|----------------------------|------------------|------------|----------------------------|------------------|------------|----------------------------|------------------|------------|----------------------------|------------------|
| 0          | 39 8                       | 15               | 128        | 12 7                       | 26               | 256        | 0 1                        | 31               | 384        | 11 52                      | 26               |
| 4          | 38 12                      | 16               | 132        | 11 27                      | 26               | 260        | 0 0                        | 31               | 388        | 12 37                      | 26               |
| 8          | 37 16                      | 16               | 136        | 10 47                      | 26               | 264        | 0 1                        | 31               | 392        | 13 23                      | 25               |
| 12         | 36 21                      | 16               | 140        | 10 9                       | 27               | 268        | 0 3                        | 31               | 396        | 14 11                      | 25               |
| 16         | 35 26                      | 17               | 144        | 9 31                       | 27               | 272        | 0 7                        | 31               | 400        | 14 59                      | 25               |
| 20         | 34 30                      | 17               | 148        | 8 45                       | 27               | 276        | 0 12                       | 31               | 404        | 15 48                      | 24               |
| 24         | 33 35                      | 17               | 152        | 8 19                       | 27               | 280        | 0 19                       | 31               | 408        | 16 38                      | 24               |
| 28         | 32 40                      | 18               | 156        | 7 44                       | 28               | 284        | 0 28                       | 30               | 412        | 17 30                      | 24               |
| 32         | 31 45                      | 18               | 160        | 7 0                        | 28               | 288        | 0 38                       | 30               | 416        | 18 22                      | 23               |
| 36         | 30 50                      | 19               | 164        | 6 38                       | 28               | 292        | 0 50                       | 30               | 420        | 19 15                      | 23               |
| 40         | 29 56                      | 19               | 168        | 6 7                        | 28               | 296        | 1 3                        | 30               | 424        | 20 9                       | 23               |
| 44         | 29 3                       | 19               | 172        | 5 37                       | 28               | 300        | 1 17                       | 30               | 428        | 21 4                       | 22               |
| 48         | 28 10                      | 20               | 176        | 5 8                        | 29               | 304        | 1 33                       | 30               | 432        | 22 59                      | 23               |
| 52         | 27 16                      | 20               | 180        | 4 41                       | 29               | 308        | 1 50                       | 30               | 436        | 22 55                      | 22               |
| 56         | 26 23                      | 20               | 184        | 4 15                       | 29               | 312        | 2 8                        | 30               | 440        | 23 53                      | 21               |
| 60         | 25 30                      | 21               | 188        | 3 49                       | 29               | 316        | 2 28                       | 30               | 444        | 24 51                      | 21               |
| 64         | 24 38                      | 21               | 192        | 3 24                       | 29               | 320        | 2 51                       | 30               | 448        | 25 49                      | 21               |
| 68         | 23 47                      | 21               | 196        | 3 1                        | 29               | 324        | 3 15                       | 29               | 452        | 26 8                       | 20               |
| 72         | 22 56                      | 22               | 200        | 2 40                       | 30               | 328        | 3 40                       | 29               | 456        | 27 48                      | 20               |
| 76         | 22 5                       | 22               | 204        | 2 20                       | 30               | 332        | 4 6                        | 29               | 460        | 28 48                      | 19               |
| 80         | 21 15                      | 22               | 208        | 2 1                        | 30               | 336        | 4 34                       | 29               | 464        | 29 49                      | 19               |
| 84         | 20 26                      | 23               | 212        | 1 41                       | 30               | 340        | 5 3                        | 29               | 468        | 30 50                      | 19               |
| 88         | 19 37                      | 23               | 216        | 1 25                       | 30               | 344        | 5 34                       | 29               | 472        | 31 51                      | 18               |
| 92         | 18 48                      | 23               | 220        | 1 10                       | 30               | 348        | 6 5                        | 28               | 476        | 32 53                      | 18               |
| 96         | 18 0                       | 24               | 224        | 0 58                       | 30               | 352        | 6 38                       | 28               | 480        | 33 55                      | 17               |
| 100        | 17 14                      | 24               | 228        | 0 47                       | 30               | 356        | 7 13                       | 28               | 484        | 34 57                      | 17               |
| 104        | 16 28                      | 24               | 232        | 0 36                       | 30               | 360        | 7 50                       | 28               | 488        | 35 59                      | 17               |
| 108        | 15 42                      | 24               | 236        | 0 26                       | 30               | 364        | 8 27                       | 27               | 492        | 37 1                       | 16               |
| 112        | 14 57                      | 25               | 240        | 0 18                       | 30               | 368        | 9 6                        | 27               | 496        | 38 5                       | 16               |
| 116        | 14 13                      | 25               | 244        | 0 12                       | 31               | 372        | 9 46                       | 27               | 500        | 39 8                       | 5                |
| 120        | 13 30                      | 25               | 248        | 0 7                        | 31               | 376        | 10 27                      | 27               | 504        | 40 11                      | 15               |
| 124        | 12 48                      | 26               | 252        | 0 4                        | 31               | 380        | 11 9                       | 26               | 508        | 41 15                      | 14               |
| 128        | 12 7                       | 26               | 256        | 0 1                        | 31               | 384        | 11 52                      | 26               | 512        | 42 17                      | 14               |

*Prima*

( 1029 )

*Primæ Equationes Conjunctionum Primi Satellitis  
cum Jove.*

| Num.<br>A. | Æquat.<br>Conjun.<br>Addē. | Æq.<br>Nu.<br>B. | Num.<br>A. | Æquat.<br>Conjun.<br>Addē. | Æq.<br>Nu.<br>B. | Num.<br>A. | Æquat.<br>Conjun.<br>Addē. | Æq.<br>Nu.<br>B. | Num.<br>A. | Æquat.<br>Conjun.<br>Addē. | Æq.<br>Nu.<br>B. |
|------------|----------------------------|------------------|------------|----------------------------|------------------|------------|----------------------------|------------------|------------|----------------------------|------------------|
| 512        | 42 17                      | 14               | 640        | 70 26                      | 3                | 768        | 77 40                      | 0                | 896        | 61 48                      | 6                |
| 516        | 43 19                      | 14               | 644        | 71 3                       | 3                | 772        | 77 29                      | 0                | 900        | 61 2                       | 7                |
| 520        | 44 21                      | 13               | 648        | 71 38                      | 3                | 776        | 77 18                      | 0                | 904        | 60 15                      | 7                |
| 524        | 45 23                      | 13               | 652        | 72 11                      | 2                | 780        | 77 6                       | 0                | 908        | 59 28                      | 7                |
| 528        | 46 25                      | 13               | 656        | 72 42                      | 2                | 784        | 76 51                      | 1                | 912        | 58 39                      | 8                |
| 532        | 47 26                      | 12               | 660        | 73 13                      | 2                | 788        | 76 34                      | 1                | 916        | 57 50                      | 8                |
| 536        | 48 27                      | 12               | 664        | 73 42                      | 2                | 792        | 76 15                      | 1                | 920        | 57 1                       | 8                |
| 540        | 49 28                      | 11               | 668        | 74 10                      | 2                | 796        | 75 56                      | 1                | 924        | 56 11                      | 9                |
| 544        | 50 28                      | 11               | 672        | 74 36                      | 1                | 800        | 75 36                      | 1                | 928        | 55 20                      | 9                |
| 548        | 51 28                      | 11               | 676        | 75 1                       | 1                | 804        | 75 15                      | 1                | 932        | 54 29                      | 9                |
| 552        | 52 27                      | 10               | 680        | 75 25                      | 1                | 808        | 74 52                      | 1                | 936        | 53 38                      | 10               |
| 556        | 53 25                      | 10               | 684        | 75 48                      | 1                | 812        | 74 27                      | 1                | 940        | 52 46                      | 10               |
| 560        | 54 23                      | 9                | 688        | 76 8                       | 1                | 816        | 74 1                       | 2                | 944        | 51 53                      | 10               |
| 564        | 55 21                      | 9                | 692        | 76 26                      | 1                | 820        | 73 35                      | 2                | 948        | 51 0                       | 11               |
| 568        | 56 17                      | 9                | 696        | 76 43                      | 0                | 824        | 73 8                       | 2                | 952        | 50 6                       | 11               |
| 572        | 57 12                      | 8                | 700        | 76 59                      | 0                | 828        | 72 39                      | 2                | 956        | 49 13                      | 11               |
| 576        | 58 7                       | 8                | 704        | 77 13                      | 0                | 832        | 72 9                       | 2                | 960        | 48 20                      | 12               |
| 580        | 59 1                       | 8                | 708        | 77 26                      | 0                | 836        | 71 38                      | 3                | 964        | 47 26                      | 12               |
| 584        | 59 54                      | 7                | 712        | 77 38                      | 0                | 840        | 71 6                       | 3                | 968        | 46 31                      | 12               |
| 588        | 60 46                      | 7                | 716        | 77 48                      | 0                | 844        | 70 32                      | 3                | 972        | 45 36                      | 13               |
| 592        | 61 38                      | 6                | 720        | 77 57                      | 0                | 848        | 69 57                      | 3                | 976        | 44 41                      | 13               |
| 596        | 62 28                      | 6                | 724        | 78 4                       | 0                | 852        | 69 21                      | 3                | 980        | 43 46                      | 13               |
| 600        | 63 17                      | 6                | 728        | 78 9                       | 0                | 856        | 58 45                      | 4                | 984        | 42 50                      | 14               |
| 604        | 64 5                       | 5                | 732        | 78 13                      | 0                | 860        | 68 7                       | 4                | 988        | 41 55                      | 4                |
| 608        | 64 53                      | 5                | 736        | 78 15                      | 0                | 864        | 67 29                      | 4                | 992        | 41 0                       | 14               |
| 612        | 65 39                      | 5                | 740        | 78 16                      | 0                | 868        | 66 49                      | 4                | 996        | 40 4                       | 15               |
| 616        | 66 24                      | 5                | 744        | 78 15                      | 0                | 872        | 66 9                       | 5                | 1000       | 39 8                       | 15               |
| 620        | 67 7                       | 4                | 748        | 78 12                      | 0                | 876        | 65 28                      | 5                | 1004       | 38 12                      | 16               |
| 624        | 67 49                      | 4                | 752        | 78 9                       | 0                | 880        | 64 46                      | 5                | 1008       | 37 16                      | 16               |
| 628        | 68 30                      | 4                | 756        | 78 4                       | 0                | 884        | 64 3                       | 5                | 1012       | 36 21                      | 16               |
| 632        | 69 10                      | 4                | 760        | 77 58                      | 0                | 888        | 63 19                      | 6                | 1016       | 35 26                      | 17               |
| 636        | 69 49                      | 3                | 764        | 77 50                      | 0                | 892        | 62 34                      | 6                | 1020       | 34 30                      | 17               |
| 640        | 70 26                      | 3                | 768        | 77 40                      | 0                | 896        | 61 48                      | 6                | 1024       | 33 35                      | 17               |

*Secundæ*

( 1030 )

*Secunda Aequationes Conjunctionum Primi Satellitis  
cum Jove.*

*Addendæ.*

| Num.<br>B.<br>Æqu. | 0           | 100         | 200        | 300        | 400        | 500        | 600        | 700        | 800         | 900         |
|--------------------|-------------|-------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
|                    | <i>Æqu.</i> | <i>Æqu.</i> | <i>Æq.</i> | <i>Æq.</i> | <i>Æq.</i> | <i>Æq.</i> | <i>Æq.</i> | <i>Æq.</i> | <i>Æqu.</i> | <i>Æqu.</i> |
|                    | "           | "           | "          | "          | "          | "          | "          | "          | "           | "           |
| 0                  | 14 0        | 12 52       | 9 45       | 5 30       | 1 37       | 0 0        | 1 37       | 5 30       | 9 45        | 12 52       |
| 4                  | 14 0        | 12 46       | 9 36       | 5 20       | 1 30       | 0 0        | 1 44       | 5 40       | 9 54        | 12 58       |
| 8                  | 13 59       | 12 40       | 9 26       | 5 9        | 1 23       | 0 1        | 1 52       | 5 51       | 10 3        | 13 2        |
| 12                 | 13 59       | 12 35       | 9 17       | 4 59       | 1 16       | 0 2        | 1 59       | 6 1        | 10 12       | 13 7        |
| 16                 | 13 58       | 12 29       | 9 7        | 4 48       | 1 9        | 0 3        | 2 7        | 6 11       | 10 21       | 13 11       |
| 20                 | 13 57       | 12 23       | 8 58       | 4 38       | 1 3        | 0 4        | 2 15       | 6 22       | 10 31       | 13 16       |
| 24                 | 13 56       | 12 17       | 8 48       | 4 28       | 0 57       | 0 5        | 2 24       | 6 33       | 10 40       | 13 20       |
| 28                 | 13 54       | 12 11       | 8 38       | 4 18       | 0 52       | 0 7        | 2 32       | 6 44       | 10 49       | 13 25       |
| 32                 | 13 53       | 12 4        | 8 28       | 4 8        | 0 46       | 0 10       | 2 41       | 6 55       | 10 57       | 13 29       |
| 36                 | 13 51       | 11 56       | 8 17       | 3 58       | 0 40       | 0 13       | 2 50       | 7 5        | 11 5        | 13 33       |
| 40                 | 13 49       | 11 49       | 8 7        | 3 58       | 0 35       | 0 16       | 2 59       | 7 16       | 11 13       | 13 36       |
| 44                 | 13 47       | 11 42       | 7 57       | 3 38       | 0 31       | 0 19       | 3 9        | 7 26       | 11 20       | 13 38       |
| 48                 | 13 44       | 11 34       | 7 47       | 3 29       | 0 27       | 0 23       | 3 19       | 7 36       | 11 27       | 13 41       |
| 52                 | 13 41       | 11 27       | 7 36       | 3 19       | 0 23       | 0 27       | 3 29       | 7 47       | 11 34       | 13 44       |
| 56                 | 13 38       | 11 20       | 7 26       | 3 9        | 0 19       | 0 31       | 3 38       | 7 57       | 11 42       | 13 47       |
| 60                 | 13 36       | 11 13       | 7 16       | 2 59       | 0 16       | 0 35       | 3 48       | 8 7        | 11 49       | 13 49       |
| 64                 | 13 33       | 11 5        | 7 5        | 2 50       | 0 13       | 0 40       | 3 58       | 8 17       | 11 56       | 13 51       |
| 68                 | 13 29       | 10 57       | 6 55       | 2 41       | 0 10       | 0 46       | 4 8        | 8 28       | 12 4        | 13 53       |
| 72                 | 13 25       | 10 49       | 6 44       | 2 32       | 0 7        | 0 52       | 4 18       | 8 38       | 12 11       | 13 54       |
| 76                 | 13 20       | 10 40       | 6 33       | 2 24       | 0 5        | 0 57       | 4 28       | 8 48       | 12 17       | 13 56       |
| 80                 | 13 16       | 10 31       | 6 22       | 2 15       | 0 4        | 1 3        | 4 38       | 8 58       | 12 23       | 13 57       |
| 84                 | 13 11       | 10 21       | 6 11       | 2 7        | 0 3        | 1 9        | 4 48       | 9 7        | 12 29       | 13 58       |
| 88                 | 13 7        | 10 12       | 6 1        | 1 59       | 0 2        | 1 16       | 4 59       | 9 17       | 12 35       | 13 59       |
| 92                 | 13 2        | 10 3        | 5 51       | 1 52       | 0 1        | 1 23       | 5 9        | 9 26       | 12 40       | 13 59       |
| 96                 | 12 58       | 9 54        | 5 40       | 1 44       | 0 0        | 1 30       | 5 20       | 9 36       | 12 46       | 14 0        |
| 100                | 12 52       | 9 45        | 5 30       | 1 37       | 0 0        | 1 37       | 5 30       | 9 45       | 12 52       | 14 0        |

*Tertia*

*Tertiae Aequationes Ad-*  
*denda.*

*Semidurationes Eclipsium Primi Satellitis*  
*Jovis.*

| Nu.<br>A. | Aequa-<br>tiones. | Nu.<br>A. | Nu.<br>A. | Semidu-<br>rationes. | Nu.<br>A. | Semidu-<br>rationes. | Nu.<br>A. | Semidu-<br>rationes. | Nu.<br>A. | Semidu-<br>rationes. |
|-----------|-------------------|-----------|-----------|----------------------|-----------|----------------------|-----------|----------------------|-----------|----------------------|
|           | "                 |           |           | H. "                 |           | H. "                 |           | H. "                 |           | H. "                 |
| 0         | 3 30              | 1000      | 0         | 1 5 9                | 250       | 1 7 0                | 500       | 1 5 9                | 750       | 1 7 46               |
| 20        | 3 29              | 980       | 10        | 1 4 56               | 260       | 1 7 15               | 510       | 1 4 53               | 760       | 1 7 57               |
| 40        | 3 28              | 960       | 20        | 1 4 44               | 270       | 1 7 31               | 520       | 1 4 39               | 770       | 1 8 7                |
| 60        | 3 25              | 940       | 30        | 1 4 33               | 280       | 1 7 45               | 530       | 1 4 26               | 780       | 1 8 15               |
| 80        | 3 19              | 920       | 40        | 1 4 23               | 290       | 1 7 57               | 540       | 1 4 15               | 790       | 1 8 22               |
| 100       | 3 12              | 900       | 50        | 1 4 13               | 300       | 1 8 7                | 550       | 1 4 7                | 800       | 1 8 26               |
| 120       | 3 4               | 880       | 60        | 1 4 7                | 310       | 1 8 15               | 560       | 1 4 3                | 810       | 1 8 28               |
| 140       | 2 56              | 860       | 70        | 1 4 4                | 320       | 1 8 22               | 570       | 1 4 1                | 820       | 1 8 30               |
| 160       | 2 46              | 840       | 80        | 1 4 2                | 330       | 1 8 27               | 580       | 1 4 0                | 830       | 1 8 28               |
| 180       | 2 34              | 820       | 90        | 1 4 0                | 340       | 1 8 28               | 590       | 1 4 3                | 840       | 1 8 26               |
| 200       | 2 22              | 800       | 100       | 1 4 2                | 350       | 1 8 29               | 600       | 1 4 7                | 850       | 1 8 22               |
| 220       | 2 10              | 780       | 110       | 1 4 3                | 360       | 1 8 27               | 610       | 1 4 13               | 860       | 1 8 16               |
| 240       | 1 57              | 760       | 120       | 1 4 6                | 370       | 1 8 24               | 620       | 1 4 23               | 870       | 1 8 8                |
| 260       | 1 44              | 740       | 130       | 1 4 12               | 380       | 1 8 17               | 630       | 1 4 35               | 880       | 1 8 0                |
| 280       | 1 30              | 720       | 140       | 1 4 21               | 390       | 1 8 9                | 640       | 1 4 49               | 890       | 1 7 50               |
| 300       | 1 17              | 700       | 150       | 1 4 31               | 400       | 1 7 58               | 650       | 1 5 4                | 900       | 1 7 37               |
| 320       | 1 5               | 680       | 160       | 1 4 42               | 410       | 1 7 46               | 660       | 1 5 19               | 910       | 1 7 22               |
| 340       | 0 53              | 660       | 170       | 1 4 55               | 420       | 1 7 31               | 670       | 1 5 36               | 920       | 1 7 8                |
| 360       | 0 41              | 640       | 180       | 1 5 9                | 430       | 1 7 14               | 680       | 1 5 54               | 930       | 1 6 55               |
| 380       | 0 31              | 620       | 190       | 1 5 23               | 440       | 1 6 58               | 690       | 1 6 10               | 940       | 1 6 40               |
| 400       | 0 22              | 600       | 200       | 1 5 39               | 450       | 1 6 40               | 700       | 1 6 28               | 950       | 1 6 23               |
| 420       | 0 14              | 580       | 210       | 1 5 55               | 460       | 1 6 20               | 710       | 1 6 46               | 960       | 1 6 8                |
| 440       | 0 8               | 560       | 220       | 1 6 11               | 470       | 1 6 2                | 720       | 1 7 2                | 970       | 1 5 54               |
| 460       | 0 4               | 540       | 230       | 1 6 26               | 480       | 1 5 45               | 730       | 1 7 17               | 98        | 1 5 37               |
| 480       | 0 2               | 520       | 240       | 1 6 43               | 490       | 1 5 26               | 740       | 1 7 33               | 990       | 1 5 22               |
| 500       | 0 0               | 500       | 250       | 1 7 0                | 500       | 1 5 9                | 750       | 1 7 46               | 1000      | 1 5 9                |

## The Use of the foregoing T A B L E S.

**T**H E Eclipses of the first Satellite of *Jupiter*, as has been already said, afford the best means of determining the Longitude of places on the Land, where Telescopes of a convenient length may be used; thirteen of these Eclipses happening every 23 Days; but it is requisite that the Observer know near the matter when these opportunities offer themselves, least on the one hand he let them slip, or else grow weary by a too long attendance on them.

Those therefore who are curious to observe them, may readily compute the times of the Immersions or Emerisions of this Satellite, and that with great exactness, by the following very short Precepts, which admit of no Exception or Caution, *viz.*

Out of the first Table take the *Epoche* for the Year, with its corresponding *Numb. A* and *Numb. B*; and to them add, out of the Tables of Months, the Day, Hour, Minute and Second, nearest less than the time of the Eclipse you seek for, together with its *Num. A* and *B*: the Sum of the times is the mean time of the middle of the Eclipse 1. With *Num. A* thus collected take out the first *Æquation* of the Conjunctions; as also the *Æquation* of *Num. B*. always to be added to *Num. B*. before found. 2. With *Num. B* so equated, take out the second *Æquation* of the Conjunctions; and in the last Table, the third *Æquation*, as also the Semi-duration of the Eclipse answering to *Num. A*. 3. To the mean time of the middle of the Eclipse, add all those three *Æquations*; the Sum shall be the true equated time of the middle of the Eclipse sought. 4. If *Num. B*. equated be less than 500, subtract the

the Semiduration, and you will have the time of the Im-  
mersion, or if it be more than 500, adding the same,  
it will give the time of the Emerſion

But Note, the times thus found are equal time, ſtill  
to be reduced to the Apparent: and that in the *Biſſex-*  
*tile* Year, after *February*, one Day is to be deducted  
from the Day of the Month.

The leſs ſkilful may perhaps be pleas'd with an  
Example or two, which may ſerve them to imitate.  
Let it be required to find the time of the Immersion  
of this Satellite into *Jupiter's* ſhadow, *November* the  
9th 1719. in the Morning. The Work ſtands thus,

|                | D. h. ' "     | Nu. A.                 | Nu. B.        |
|----------------|---------------|------------------------|---------------|
| 1719.          | 1. 6. 11. 13  | 872                    | 396           |
| <i>Novemb.</i> | 7. 11. 53. 29 | 72                     | 776           |
|                | <hr/>         | <hr/>                  | <hr/>         |
| Conj. Med.     | 8. 18. 4. 42  | 944                    | 172           |
| Æquat. I.      | 51. 53        |                        | 10 Æq. B.     |
| Æquat. II.     | 10. 26        |                        | 182 B. Æquat. |
| Æquat. III.    | 3. 26         |                        |               |
|                | <hr/>         |                        |               |
|                | 8. 19. 10. 27 |                        |               |
|                | 1. 6. 33      | <i>Semidur. Subſt.</i> |               |
|                | <hr/>         |                        |               |
| <i>Novemb.</i> | 8. 18. 3. 54  |                        |               |

So that by this *Calculus*, on the ninth of *Novemb.*  
at 4 Minutes after 6 in the Morning, equal Time,  
may be ſeen the *Immersion* of this Satellite into *Jupi-*  
*ter's* ſhadow.

Another Example ſhall be of the *Emerſion* on the  
fifth of *April* 1720. viz.

( 1034 )

|              | D. h. ' "            | Nu. A.               | Nu. B.        |
|--------------|----------------------|----------------------|---------------|
| 1720.        | 0. 20. 22. 40        | 956                  | 310           |
| <i>April</i> | <u>4. 13. 44. 22</u> | <u>Bis. 22</u>       | <u>244</u>    |
| Conj. Med.   | 5. 10. 07. 02        | 978                  | 554           |
| Æquat. I.    | 44. 13               |                      | 13 Æq. B.     |
| Æquat. II.   | 0. 45                |                      | 567 B. Æquat. |
| Æquat. III.  | 3. 29                |                      |               |
|              | <u>1. 5. 40</u>      | <i>Semidur. Add.</i> |               |
| <i>April</i> | 5. 12. 01. 09        |                      |               |

Hence it appears that at one Minute after Mid-night following the fifth of *April*, equal Time, will happen the Emerfion required. Nor do we doubt but that the Event will very nearly answer.

Laftly, it may not be amifs here to inform the Reader, that we have learnt, by the experience of many Years Obfervation, that the fecond inequality of this Satellite proceeds from the progrefſive Propagation of Light, and is common to all the reſt of the Satellites: Light, being found to proceed in about ſeven Minutes of time as far as from the Sun to the Earth, whether with an equable motion or otherwife is ſtill a queſtion. For this reaſon we have added a *Third Equation*, whereby to account for the greater diſtance of *Jupiter* from the *Earth* in *Aphelio* than in *Perihelio*, as the *Second Equation* answers to the greater diſtance of the Planet when near the Conjunction of the Sun, than when near his Oppofition.

F I N I S.

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# PHILOSOPHICAL TRANSACTIONS.

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For the Months of September and October 1719.

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- II. *Epistola D<sup>ni</sup>. Jacobi Jurin, M. D. & R. S. Socii, quâ doctrinam suam De Potentia Cordis, contra nuperas Objectiones Viri Clariss. D. Jacobi Keillii, M. D. in Num. 361. Philos. Transact. editas, defendit.*
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- I. *A Letter of the curious Mr. Henry Barham, R. S. Soc. to Sir Hans Sloan, Bart. Vice-President of the Royal Society; giving several Experiments and Observations on the production of Silk-Worms, and of their Silk in England, as made by him last Summer.*

*Worthy Sir,*

**A**S you are the Patron of Industry and encourager of Natural Experiments, I think you justly claim the first View of these small ones, I made upon *Silk Worms*, the last Summer.

And altho' they may have been done before by others in some other parts of the World; yet in all the Authors I have Read I do not find they make use of the same Method; and I dare be bold to say, that these following Observations and Experiments were never made in *England* with that Nicety, as I have done, and shall do if I live. It being the first Attempt of this kind, it may come short of that compleat Methodical Manner it may be brought to hereafter; the which I hope you'll excuse.

After you have perused it your self, if you see any thing in it worthy the Communicating to the *Royal Society* (it being design'd for the Publick) you may do me the Honour. But I wholly submit to your Judgment and Opinion in this, as I do in all other things whatsoever. I am,

*Your humble Servant*

Henry Barham.

**E**Xperiments made in *Chelsea Park*, in the Months of *May June and July 1719.*

*April 27.* I receiv'd a small parcel of *Silk-Worms Eggs* from *Languedoc.*

*May 6.* Early in the Morning I found them Hatcht of themselves, the Wind shifting in the Night from *East Northerly* to the *West Southerly*, changing the Air of a sudden to Warm, two Days before the change of the Moon.

After Feeding and Managing them according to Art, through the whole Course of their four Sickneses, they were come to their State of Perfection, being then as thick as a Man's little Finger, and from 4 to 5 Inches long, of a yellowish Colour, and when held against the Light, they

mights

might be seen through as you may an Egg, being of the same Colour and Consistence (fill'd with the matter that makes the Silk) This is a certain Sign that they will begin to Spin in 24 Hours or less. They then forsake their Food (being very Voracious before) and hunt about for a convenient Place to fix their first Hold-fasts, for supporting the Balls or Cones that they are to make, which they do in a most wonderful Mathematical Manner, with a Mixture of a Gummy Substance that ties all together; and when the loose furzy Substance is taken off, and some of the Silk is wound off, the remainder is so Smooth and Compact, shining like *Sattin*, that they are made use of for Artificial Flowers, and esteemed the best of any thing yet known for that purpose, for which (only) they are generally kept in *Boarding Schools*. I weighed many hundreds of these Silk-Balls or Cones, which I found to weigh from 35 to 40 Grains, with their *Aurelia's* or *Chrysalis* within them.

*June 27.* They begun to Spin, having been Hatcht 7 Weeks and 3 Days; and in 4 or 5 Days finished their laborious and curious Work: but their Balls were not fit to be removed until 8 or 10 Days.

*July 7. Mons. Lachivre* began to wind off their Silk-Balls with a Machine that made great dispatch, winding much fine Silk in a Day: I found that an Ounce of Silk-Balls would make about a Dram of fine Silk; but to be more certain, I weighed out to the Winder 12 Pounds of Silk-Balls at 4 times, and told the Balls in every 3 Pound as followeth, *viz.*

|                              |           |
|------------------------------|-----------|
| The first 3 Pound contained  | 812 Balls |
| The second 3 Pound contained | 842       |
| The third 3 Pound contained  | 797       |
| The fourth 3 Pound contained | 868       |

So that the whole 12 *lib.* Weight contained 3319 Balls.

Which when wound off, was found to yield and make one Pound and one Ounce, or 17 Ounces of fine Silk, and about 7 Ounces of coarse Refuse unwound, in all a Pound and half of *Averdupois* Weight, or 2 Pounds *Troy*; which is as great or greater making or yielding as in any part of the World, and the Silk as fine. I shewed it to a noted *Silk Broker*, who said it was *Italian* Silk, (not knowing it was made in *England*) and worth about 20 *Shillings* per Pound, if I had never so many Bales of it, &c.

Now

Now upon this Experiment finding that 3319 Silk-Balls would make one Pound and one Ounce of fine Silk. I was desirous to know what quantity of Silk might be expected from the Worms Hatched from one Ounce of Eggs.

Of which to obtain the Knowledge, I made use of the following Method: by often weighing and telling I found that one hundred Eggs weighed but one Grain, so that if one Grain contains 100, a Scruple must contain 2000, and a Dram 6000, and an Ounce at 8 Drams to the Ounce, must contain 48000 Eggs. Now if every Egg hatch a Worm, and every Worm makes a Silk-Ball, there must be from one Ounce 48000 Silk-Balls; and if 3319 Balls will make one Pound and one Ounce of fine Silk, (which by Experience I found they did) then 48000 Silk-Balls will make 15 Pounds and 6 Ounces of *Averdupois* Weight in fine Silk, or 18 Pounds and eight Ounces of *Troy* Weight, which is very considerable. And in the same Proportion one Pound of *Silk Worms* Eggs, will produce Worms sufficient to make above 180 Pounds of Silk. But allowing for Casualties, and supposing but 12 Pound of fine Silk made from the Worms and their Silk-Balls produced from an Ounce of *Silk Worms* Eggs; it will be found much to exceed most Countries, according to *Augustino Gallo's* Computation: For he sayeth, that in the Southern parts of *France*, viz. *Languedoc* and *Provence*, they make but 7 or 8 Pound of Silk from *Silk Worms* hatched from an Ounce of Eggs; and in *Brescia* in *Italy*, but 8, 9, or 10 Pound of Silk from an Ounce; only in *Calabria*, where the *Silk Worms* and their Eggs are larger, they make 11 or 12 Pounds of Silk from an Ounce of Eggs; which still doth not exceed, nay hardly comes up to, what we make in *England*.

As to the Charge and Expences of making the aforesaid quantity of Silk in *England*, different from that of other Places, I shall be able to give you a more particular Account in my next Experimental Observations.

I have only this to add, that Experience hath taught me how to hatch *Silk Worms* twice in a Year, so as to have two good Crops of Silk in one Year. And that the *Mulberry* Trees will have Leaves in *England* twice in a Year, without prejudice to either Tree or Fruit, is most certainly true. But more in my next.



Viro Celeberrimo,

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*Jacobus Furin, M.D. & Reg. Soc. S.*

**A** Pologiam Præstantissimi Viri, *Jacobi Keilii*, qui acerbâ nuper & immaturâ morte præreptus magnum sui desiderium Eruditis reliquit, studiose pervolvimus. Quam inter legendum singularem simul candidissimi Ingenii humanitatem, quâ nosmet, utut à placitis suis dissentientes, excipere dignatus est, simul Animi magnitudinem, & studium in Rempublicam Literariam tanto Viro dignum, magnâ admiratione prosequebamur. Huic enim ille non solum per omnem vitæ cursum diligentem & strenuam operam navavit, sed etiam pulcherrimo Exemplo, confectus jam atroci morbo & se perire sentiens, eruditam illam Epistolam tanquam supremi amoris pignus, eidem legavit. Cui tamen necessario nobis respondendum est, non sane quod acerrimo tuo Judicio diffidamus, sed ne aliis Lectoribus minus idoneis impedimento esse possit, ad rectam sententiam ferendam, Viri illius Doctissimi Auctoritas. Accipe igitur, Vir Clarissime, quæ in ejus defensione minus recte tradita censemus, & tuum simul Arbitrium esto, utrum contentionis abrepti studio iniquiores

simus ipsius Manibus, an ita disputemus, ut qui de Veritate potius quam de Victoriâ simus solliciti.

Queritur primo Vir Clarissimus, quod sese una cum Doctissimis Viris *Borello*, & *Morlando*, tanquam Cordis Motum cum pondere inerti conferentem, injuste perstrinxerim. Ego certe, cum prius notassem Motum quendam Sanguinis & Arteriarum ex Cordis Vi oriri, dixi tandem sciri non posse Cordis Potentiam quanta sit, nisi Motus hujusce quantitatem cognitam teneamus: Motum vero quemlibet cum pondere quiescente comparari non magis posse, quam Lineam cum Rectangulo. Quibus verbis id significare volui, Doctissimos Viros non quidem diserte Motum Cordis cum pondere quiescente comparare, sed ipsos, cum Cordis Potentiam per pondus exponerent, nullam ostendisse rationem, quâ Motûs quantitas ex Cordis Potentiâ oriundi posset æstimari. Ex hac Objectione, si recte assessorum mentem Viri Clarissimi, ita sese expedire conatur. Cordis Potentia in pressione consistit, eamque æquabiliter in Sanguinem impendit, eodem prorsus modo, quo Gravitatis vis deorsum pondus impellit, & actione perpetuâ in motum accelerat. Proinde, cum Cordis Potentia ponderi per Corollarium *Newtonianum* definito æqualis est, ea Motum eundem durante Systole in Sanguinem imprimet, quem pondus istud eodem tempore cadendo per Gravitatis Vim comparabit. Ita vero cum mentem suam exponit Vir Cl. sublatum iri penitus Objectionem istam nostram confitemur; si nimirum Cordis Potentia prædicto ponderi æqualis sit, eademque consistat in æquabili pressione per totam Systolen continuatâ. Atqui ex duabus istis Propositionibus posteriorem neutiquam probare conatur Vir Doctissimus, sed Hypotheseos loco ponit; quamvis nos rationibus quibusdam adductis contrariam Sententiam conati sumus verisimiliorem reddere; nempe, quod Cordis Potentia nequaquam æquabiliter agat

in Sanguinem per totam Systolen, sed cum totas vires exiguâ temporis particulâ collegerit, inde uno impetu in Sanguinem irruat, eumque ex Ventriculis expellat, eo modo quem in Dissertatione nostrâ Epistolari fusius exposuimus. Priorem vero Propositionem, etiam concessâ Viro Cl. istâ Hypothesi, falsam esse mox demonstrabimus.

Corollarii *Newtoniani* sensum quod attinet, nolumus Lectori molestiam nimiam facessere, cum neque putemus ejus interesse uter *Newtoni* mentem rectius acceperit; neque ita perspicue sententiam suam exposuerit Doctissimus Adversarius, quin periculum sit, ne aliquem ei sensum affingamus, quem ipse forsitan, si posset adhuc se defendere, foret repudiaturus. Id vero adnotasse operæ pretium erit, quod cum loquatur *Keillius* de Vi quâ ex Orificio aliquo aqua exprimitur, *Newtonus* nullum omnino verbum in isto Corollario posuerit, quo Aqua per Vim aliquam exprimi significetur; sed pondus solum determinaverit æquale illi Vi, quâ totus Aquæ effluentis Motus generari potest, sive quod Gravitatis Vi cadendo Motum comparare potest Motui aquæ eodem tempore effluentis æqualem.

Quod autem Corollarium illud, si non male intellexerit Vir Cl. certe non satis apte usurpârit, facile perspiciet Lector Eruditus, qui animum adverterit, quid intersit discriminis inter effluxum aquæ ex foramine in fundo vasis semper pleni, quomodo à *Newtono* consideratur in eo Corollario, & effluxum Sanguinis ex Corde in Aortam. In casu enim priori aqua jam totam velocitatem comparavit, & per datum temporis spatium æquabiliter effluit ex foramine. At Cordis Vis per Hypothesin *Keillianam*, applicatur Sanguini in Ventriculo quiescenti, & cum primo temporis momento velocitate infinite parvâ versus Aortam propellit; continuatâ vero æquabili pressione tandem ei finitam ve-

locitatem imprimit, eamque perpetim auget, donec omnem Sanguinem ex Ventriculo expulerit.

Rursum in casu *Newtoniano* consideratur Motus non quidem totius aquæ Cataractâ contentæ, quæ omnis in motu constituta est, & diversa velocitate versus exitum tendit, sed aquæ solum in ipso foramine positæ & jam exilientis. Vis autem Cordis toti Sanguinis moli Ventriculo contentæ Motum imprimit, totamque Aortam versus propellit.

Denique negamus pondus quinque unciarum, à Viro Cl. determinatum, posse eam Motus quantitatem durante Cordis Systole per Gravitatis Vim comparare, quam Cordis Potentia producit, concessâ etiam ei Hypothesi istâ, quod Cordis Potentia in æquabili pressione consistat. Per hanc enim Hypothesin erit Motus à Ventriculi sinistri Potentiâ productus, ex Calculo nostro [*Transf.* Numb. 359. p. 932, 934.] æqualis Motui Ponderis Octodecim librarum circiter, quod singulis minutis secundis longitudinem uncialem percurrat. Motus autem, quem pondus quinque unciarum durante Cordis Systole, si tollatur omnis Arteriarum & Sanguinis præcedentis resistentia, sive decimâ parte minuti secundi, per Gravitatis Vim comparabit, æquabitur fere Motui Ponderis duodecim librarum, quod suprapositâ velocitate moveatur. Quod si cui libuerit adsumptâ hâc Hypothesi verum pondus definire, quod Cordis Potentiæ æquale est, is posito Calculo eliciet pondus unciarum circiter septem cum semisse. Hoc enim durante Systole Cordis eundem fere Motum cadendo comparabit, quem producit ipsa Cordis Potentia.

Sed inquiet forsitan aliquis discrimen modo expositum inter Motum à *Keilliano* pondere acquisitum, & Motum ex Potentia Cordis oriundum inde proficisci potuisse, quod forte minus accuratæ fuerint positiones illæ, quibus Characteres Algebraicos in Calculo nostro ad numeros

revo-



revocavimus. Cui dubio ut occurramus, & ostendamus simul nos longe majus discrimen inventuros fuisse, nisi contigisset ut positiones istæ *Keillio* faverent; operæ pretium erit casum aliquem simpliciore adsumere, quæ data moles aquæ, per datum orificium, dato tempore, per vim aliquam sive pressionem æquabilem exprimatur, quæ sunt conditiones ab Adversario positæ ad Potentiam Cordis definiendam.

In eo autem casu demonstrabimus neque Motum aquæ effluentis, neque Motum toti tandem moli aquæ per Vim illam impressum, Motui aquæ in Corollario *Newtoniano*; neque Vim eam sive pressionem, ponderi per istud Corollarium definito, æquari. Quod si præstare licuerit, corruat funditus necesse est tota demonstratio *Keilliana*.

Adsumemus igitur Cylindrum aquæ datum, tubo Cylindrico infinitæ longitudinis contentum; eritque pro orificio ista sectio tubi ad quam pertingit utralibet aquæ superficies, alteri autem superficiei Vis applicabitur ope Emboli eadem Diametro cum ipso tubo. Perfluat jam dato tempore data quævis aquæ quantitas per dictam sectionem tubi; tum alia quantitas æqualis per foramen pari Diametro factum in fundo vasis, quod more *Newtoniano* usque plenum conservatur: & primo loco dispiciamus, utrum pares futuri sint in utroque casu Motus aquæ effluentis.

\* Exponatur tempus effluxus aquæ per rectam A C, velocitas autem æquabilis, qua aqua effluit ex foramine in fundo vasis per rectam A B. Unde moles aquæ effluentis ex foramine, cum sit in ratione temporis & velocitatis conjunctim, exponetur per Rectangulum A B C D; & Motus ejusdem exponetur per solidum Parallelepipedon, ex eodem Rectangulo ducto in altitudinem A B, quippe qui sit in ratione composita ex rationibus molis & velocitatis.

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\* Vide Fig. II.

In casu altero, ubi aqua per tubum Cylindricum fluit, tempus, ut prius, exponetur per eandem rectam AC; velocitas autem aquæ erit in ratione temporis, quippe cum vis adhibita, ex Hypothesi, in datam aquæ molem æquabiliter agat, & proinde repræsentabitur per rectam mutabilem FG, rectæ AF, sive tempori ab initio effluxus, proportionalem. Molecula autem aquæ, particulâ temporis FH prædictam sectionem præterfluens, exponetur per Rectangulum ex ipsâ FH ductâ in exponentem velocitatis FG; vel si evanescere intelligatur rectula FH, per Trapezium FGIH. & moles aquæ toto tempore AC præterfluens significabitur per Triangulum rectangulum ACE. Et quoniam ex Hypothesi moles ista moli aquæ in casu priore effluentis aqualis est, erit Triangulum ACE æquale Rectangulo ABDC; unde CE, sive velocitas acquisita in fine temporis AC, dupla erit velocitatis CD sive AB, quâ aqua ex foramine in fundo vasis effluebat. Motus autem aquæ particulâ temporis FH præterlabentis, cum sit in ratione molis & velocitatis conjunctim, exponetur per Prisma evanescens, quod fit ex Trapezio FGIH ducto in velocitatem FG: Unde totus Motus aquæ toto tempore AC præterfluentis exponetur per Pyramidem, cujus basis est Quadratum rectæ CE, cujusque altitudo perpendicularis est ipsa AC. Quæ Pyramis cum sit ad Parallelepipedon casu priore definitum, ut 4 ad 3, erunt quoque Motus aquæ effluentis in utroque casu in eadem ratione, & proinde inæquales, quod primo loco demonstrandum susceperamus.

Proximum est, ut ostendamus Motum tandem impressum toti aquæ tubo contentæ non esse æqualem Motui in exemplo primo determinato. Hic autem, cum tota ista moles aquæ per positiones supra scriptas neutiquam definita sit, adsumemus eam æqualem moli expositæ per Rectangulum ABCD, quæ in casu

*Vide Fig. II.*

primo

primo effluit ex foramine, quæque in secundo sectionem dictam præterfluit. Unde cum totus Motus ei tandem impressus sit in ratione molis & velocitatis in fine acquisitæ, idem exponetur per Parallelepipedon ex Rectangulo  $ABDC$  ducto in rectam  $CE$ . Hoc autem est ad Parallelepipedon, primo casu definitum, ex eodem Rectangulo & rectâ  $CD$ , ut altitudo  $CE$  ad altitudinem  $CD$ , sive in ratione duplâ. Porro, cum molem aquæ tubo contentæ per quodvis aliud Rectangulum, loco Rectanguli  $ABCD$ , exponere licuisset, pater inde Motum hunc posse quamlibet rationem ad Motum primo casu definitum obtinere, & idcirco nequaquam eidem esse æqualem. Quod erat secundo loco demonstrandum.

Superest, ut ostendamus Vim in hoc casu adhibitam ponderi per Corollarium *Newtonianum* definito non esse æqualem. Hæc autem Vis & vis Gravitatis agens in istud pondus, cum ambæ sint æquabiles, erunt in ratione Motuum ex iisdem dato tempore productorum. Quos cum inæquales esse modo demonstratum sit, erunt illæ Vires itidem inæquales. Quod erat demonstrandum postremo.

Pergit Vir Cl. ad alterum illud vitium, quod ego in ejus solutione reprehenderam, nempe quod velocitatem Sanguinis ex Corde effluentis æquabilem posuerit, quam insigniter inæqualem fieri à me demonstratum est. Negat autem se æquabilem velocitatem Sanguini tribuisse, sed pro summâ diversarum omnium velocitatum velocitatem mediam usurpasse. Præterea nondum satis sibi constare dicit, utrum æqualis vel inæqualis sit Sanguinis ejecti velocitas, sed quæ pro æquali velocitate stat ratio, eam sibi firmiorem videri. Utrum vero, qui velocitatem Sanguinis inventurus molem Sanguinis expulsi ad orificium Aortæ applicat, nullâ faciâ mentione neque diversarum velocitatum, neque veloci-

tatis

tatis mediæ, velocitatem Sanguinis æquabilem ponat, penes æquum Lectorem sit Judicium. Idem quoque facile æstimabit, utrum Vis aliqua sive pressio fluido in vase quiescenti applicata, quæ est Hypothesis Viri Doctissimi, id fluidum primo temporis momento, eâdem velocitate quâ in fine, propulsura sit.

Postquam ita satisfactum putat Vir Cl. iis Objectionibus, quas contra priorem suam Methodum attuleram, jam ad alteram illam faciliorem vindicandam accedit. In hac Ego animadverteram Virum Cl. adsumere istam Propositionem, quod Vires Cordis in diversis Animalibus sint in ratione ponderum, item ponere velocitatem Sanguinis ex secâ Iliacâ Arteriâ profluentis æqualem ei, quâ Sanguis ex Corde in Aortam emittitur; quas ambas positiones falsas esse nobis demonstratum est. Vitium posterius non defendit Vir Cl. prius vero tuetur *Borelli* & aliorum Doctorum Vidorum auctoritate, qui assumptionem istam sæpius usurparunt. Ita quidem, & nos ejusmodi assumptionem in *Borello* reprehendimus, neque valet cujusquam auctoritas contra legitimam demonstrationem. Superest ergo Viro Cl. ad examen revocanda nostra demonstratio. Hanc autem fallaci quodam Principio inniti putat, quo cum omnia Theoremata nostra superstructa sint, communi ruinâ omnia involvit. Ait enim me ponere, quod Ventriculi Cordis, tanquam solidum corpus datâ velocitate motum, in Sanguinem impingunt, eoque ictu Motus sui partem eidem communicant. Quam Hypothesin Motui neque Sanguinis, neque Cordis, neque Aeris ex Pulmone expressi, competere censet Vir Clarissimus.

Quod Pulmonem attinet, quoniam hoc obiter attingere voluit Vir D. agnosco me considerasse Pulmonem inter contrahendum tanquam datâ velocitate impingentem in Aerem contentum, idque consulto fecisse profiteor.

Quum

Quam enim tum *Bellinus*, tum alii multi Viri Doctissimi, quos inter eminet Cl. Adversarius, multa protulerint de Vi illâ, quâ Aer inter expirandum in Sanguinem Pulmones præterfluentem agit, ejusque moleculas dissolvit; quam solutionem ipso expirationis initio censent accidere; mihi propositum erat hanc ipsorum sententiam ad trutinam revocare. Videbam autem, quod, si aerem per Vim æquabilem sive pressionem expelli statuerem. Motus aeri à Pulmone impressus initio expirandi, sive reactio aeris in Pulmonem, adeoque in Sanguinem præterfluentem, pro quantitate infinite parvâ habenda erat, adeoque nihil omnino eorum effectuum, quæ ipsi adscribebantur, præstare poterat. Ita vero si fecissem, jure questuros putabam *Bellini* sequaces, quod inique secum ageretur; quippe cum rejiceretur ipsorum sententia propter demonstrationem ex Hypothesi arbitrariâ & eâdem omnium adversissimâ deductam. Malui igitur ex illâ Hypothesi demonstrationem deducere, quæ omnium maxime ipsis faveret, maximamque Morus quantitatem expirandi initio aeri tribueret. Hæc autem erat, quâ ponebatur Pulmo initio expirationis datâ velocitate in Aerem impingere.

Cæterum in Potentiâ Cordis definiendâ istam quidem Hypothesin, quâ ipsius Ventriculi, omni impetu momento temporis concepto, tanquam solidum corpus datâ velocitate præditum, in Sanguinem irruunt, primo loco propono, tanquam omnium simplicissimam, ex eâque solutionem deduco. Atqui deinde considero tum eam Hypothesin, quâ Ventriculi Cordis Motum omnem suum particulâ temporis admodum parvâ concipiunt, quæque mihi veri simillima videtur, tum ipsam Hypothesin *Keillianam*, atque alias infinitas, iisque omnibus solutionem meam accommodo. Adeo ut, sive istud Principium incertum & fallax, sive verum & stabile

reperiatur, nihil exinde solutionis nostræ certitudini detrahatur.

Non tamen videmus aliquid argumenti allatum, quo minus istam positionem nobis adhibere, pari jure atque Viro Cl. contrariam illam de Vi sive pressione usurpare licuerit. Nihil sane spatii inter parietes Ventrliculorum & Sanguinem intercedere non diffitemur, & tamen quare res ictu peragi nequeat nondum liquet. Certe, si Cubo Globum contingenti ictus imprimatur, Cubus partem Motus sibi impressi Globo communicabit pari facilitate, ac si spatium inter eos intercesserit.

At hæc sunt corpora solida, & ubi de fluidorum Motu agitur, longe alia res est. Discrimen sane inter ictus corporum solidorum, & actionem sive solidi in fluidum, sive fluidi in solidum, fusius exponit Vir Cl. quod discrimen cum me minus advertisse censeat, ex eo fonte fluere pronunciat quicquid Erroris in meis Propositionibus continetur. Ego vero differentiam istam ut recte traditam a Viro Cl. lubens admitto, & aio me communem illam doctrinam neutiquam ignorasse, cum nihil frequentius in Mechanicis scriptoribus occurrat, sed casus quosdam novos exposuisse, quibus ea doctrina cum adhiberi nequiret, alia erat ineunda ratio atque hætenus fuerat usurpata. Ea tribus verbis absolvi potest. Nam, ut exemplo facillimo utamur, quiescere ponatur Cylindrus aquæ datæ longitudinis in dato tubo, & moveatur per istum tubum Cylindrus alius solidus pari diametro, ac datâ velocitate in Cylindrum aqueum impingat. Quid inde futurum est? Nempe totus Cylindrus aquæ eo ictu in motum ciebitur, pari ratione, ac si fuisset & ipse solidus Cylindrus: alter vero Cylindrus Motus sui partem momento temporis deperdet, & ambo Cylindri communi velocitate per tubum deferentur. Simili modo res eveniet, si Cylindrus aqueus per tubum fluens Cylindro solido quiescenti

centi impegerit. Quod si Cylindrus aqueus data velocitate per tubum feratur, eique occurrat Cylindrus solidus aliâ velocitate, ita ut quantitates Motuum Cylindri aquei & solidi utrinque pares sint, jam momento temporis destruetur utriusque Cylindri Motus, pariter ac si duo solida corpora æquali Motu prædita sibi mutuo occurrant. Casus magis compositos quoscunque ex dissertatione nostrâ de Motu Aquarum fluentium facile eruet Lector Eruditus, idemque simul videbit, quomodo id fieri possit, quod Adversarium Cl. præcipue torfisse videtur, nempe, quod Sanguinem toto impetu ex Ventriculo ruentem sisti posse docuerim, occurrente in contrarium corpore solido datâ Motus quantitate prædito.

Quod autem nos amicè admodum hortatur Vir Candidissimus, ut sepositâ nostrâ de Vasorum ictu Hypothesi, & Vi pressuræ, quâ Naturam uti censet, pro Principio adhibitâ, Theoremata alia construamus; id profecto, nisi gravi morbo impeditus perfunctorie prorsus evolvisset nostram Dissertationem, dudum à nobis præstitum animadvertere potuisset. Quum enim ponimus Motum Cordis in ratione temporis augeri, eâdem utique Hypothesi utimur, ac si Vim pressionis adhibeamus. Hoc autem posito, Motum ex Cordis Potentiâ oriundum determinavimus, duplo scilicet majorem quam ubi Ventriculorum ictu res peragitur. Calculum vero ipsum, ut satis facilem & priori nostro similem, Lectori reliquimus instituendum. Quæ autem sequuntur Theoremata & in iis Theorema quintum, quod rejiciendum statuit Vir Cl. tanquam ex Hypothesi de Ventriculorum ictu deductum, neutiquam pendent ex istâ Hypothesi, sed ex ipsâ Hypothesi Doctissimi Adversarii pari facilitate demonstrantur.

Nequaquam dubitamus, quin ipse Vir Cl. quid ista veri habeant, si in vivis adhuc ageret, pro suâ sagaci-

tate facile perspecturus foret ; jam vero, quoniam egregium illud Rei Medicæ Lumen amisimus, eadem aliis Eruditis perpendenda simul proponimus & dijudicanda. Tibi præsertim, Vir Doctissime, cujus auctoritatem & ille plurimi fecit, & nos præcipuam habemus, Judici simul integerrimo & maxime idoneo, totam istam disputationem lubentissime subjicimus.

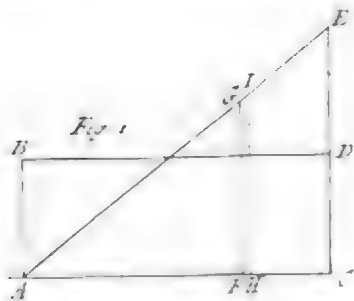
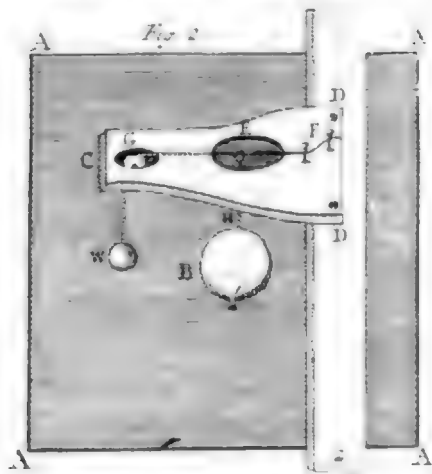
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### III. *Methodus Differentialis Newtoniana Illustrata.* *Authore Jacobo Stirling, è Coll. Balliol. Oxon.*

**A** Rithmeticæ pars præcipua consistit in inveniendâ in numeris quantitate quâcunque determinatâ ; cum vero quantitatum & numerorum natura non patiatur ut omnes quantitates exhibeantur in numeris accurate, necesse habemus ad Approximationes confugere. Hoc est, ubi quantitatum valores mathematicæ accurati nequeunt obtineri, quærendi sunt ii qui ab accuratis distant minus datâ quâvis differentiâ.

Quicquid hæc de re à Veteribus ad nos pervenit, vel est particulare, ut Methodus eorum reducendi *Æquationes Quadraticas* ; vel saltem usibus generalibus male destinatum, ut Methodus Exhaustionum. *Vieta* quidem primus erat qui aliquid generale in hæc arte assequutus est : quippe invenit methodum reducendi *Æquationes Rationales*, quæ solæ tunc in usu erant. In hæc acquievêre omnes *Geometræ* ex ejus temporibus usque ad ea *Newtoni*. Hic ex *Interpolationibus* primo pervenit ad *Series* : quas postea ad reductionem *Æquationum* omnium omnino generum universaliter applicuit. Hæc autem methodus procedit per quantitatum nascentium & evanescentium rationes primas & ultimas, seu si ita loqui liceat, per quantitatum coincidentium





cidentium differentias infinite parvas. Sed & ulterius promovit *Newtonus* hanc methodum; docuitque quæ ratione approximandum sit ad quantitates quæ determinantur per regularem seriem terminorum, non per *Æquationem* ut vulgo fit. Atque sic posuit fundamenta calculi hujus Differentialis, qui procedit per quantitatum differentias cujuscunque magnitudinis: ideoque est methodo Serierum universalior. Per hæc artes *Newtonianas*, universa doctrina Approximationum reducitur ad solutionem Problematis, *Invenire Lineam Geometricam quæ per data quocunque puncta transibit*. Ex hujus inquam solutione inveniuntur radices *Æquationum* quarumcunque, & etiam quantitates quarum relationes ad alias datas per nullas *Æquationes* hactenus notas possunt exprimi. Existimo igitur *Newtonum* perduxisse methodum Approximandi ad summum perfectionis fastigium; dum ex unico simplicissimo principio totam hanc doctrinam longe lateque patentem deducit. Quapropter credendum est animum *Newtoni* non satis perspectum fuisse iis, qui ejus methodos appellant particulares, & alias tanquam suas & solas genuinas atque generales venditant, quæ aliæ non erant quam Corollaria facillima à *Newtonianis*.

Author noster, in Epistola ad *Oldenburgum*, Octob. 24. 1676. data, mentionem fecit de methodo expeditâ duccendi Lineam Parabolicam per data quocunque puncta; qua dixit se usum fuisse ubi Series simplices non sunt satis tractabiles. Et hanc methodum primo publicavit in Lemmate quinto Libri tertii *Principiorum*. Atque in Lectionibus publicis, circa idem tempus quo dicta Epistola scripta est, *Cantabrigiæ* habitis, exposuit modum generalem determinandi Curvas cujuscunque generis quæ transibunt per totidem data puncta quor earum natura patitur. Hæ Lectiones sub titulo *Arithmetica Universalis* anno 1707. publicatæ sunt, ubi habetur

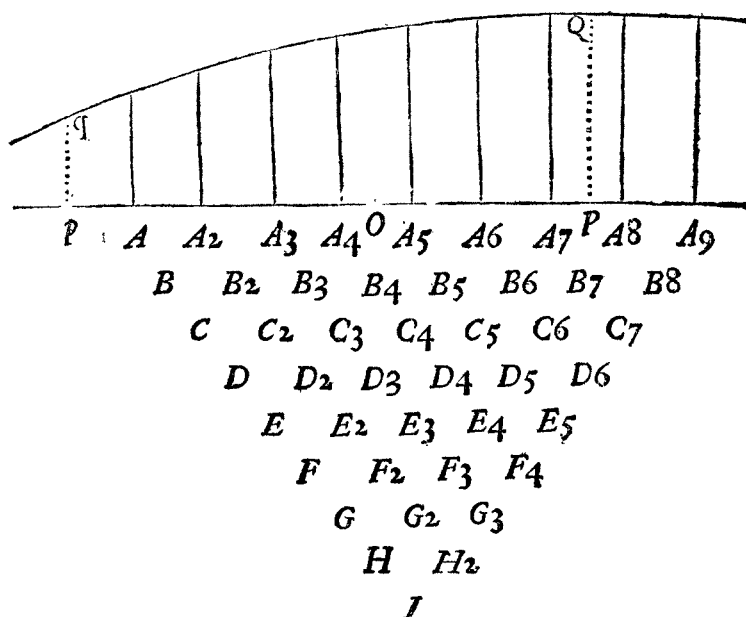
betur methodus exemplis illustrata in sectionibus Conicis. Anno vero 1711. tandem prodiit, inter alios ejusdem Authoris tractatus, ipsa Methodus Differentialis plenius quam ante exposita, cum fundamento ejus demonstrato

*Archimedes* in methodo Exhaustionum, *Cavallerius* in methodo Indivisibilium, & *Wallisus* noster in Arithmetica Infinitorum, posuerunt fundamenta doctrinæ de determinanda quantitate quæsitâ per locum quem obtinet inter terminos in data Serie: at qua ratione approximandum esset ad valores quantitatum sic determinatarum. horum nemo docuit; Hoc primus & solus perfecit *Newtonus*: atque exinde haud parum ampliata est universa Analysis. Nam sicut ante hoc inventum, ea Problemata Arithmetica sola pro solutis habebantur, ubi relatio quantitatis quæsitæ ad alias datas definiebatur Æquatione. jam pro solutis habenda sunt non minus ea, in quibus quantitas quæsitâ locum datum sortitur inter terminos datæ Seriei; siquidem numeri desiderati non minus accurate obtinentur per Methodum Differentialem, quam per extractionem Radicum: hisce vero habitis, parum interest quomodo ad eos devenitum est. Et experientia multiplex docuit, quod plurima Problemata ad Æquationes ægre deducuntur, dum ad methodum Differentialem facillime. Qualis est ex multis aliis toties decantata Circuli Quadratura; quam tam perfectam, mea opinione, *Wallisus* in Arithmetica Infinitorum exhibuit quam *Archimedes* illam Parabolæ.

*Propositio*

## Propositio.

*Invenire Lineam Parabolicam quæ transibit per extrema Ordinatorum quocunque æquidistantium.*



## Casus Primus.

Designent  $A, A_2, A_3, A_4, A_5, A_6, A_7, A_8, A_9$ , &c. Ordinatas æquidistantes insistentes Abscissæ in dato angulo. Collige earum differentias  $B, B_2, B_3, B_4, B_5, B_6, B_7, B_8$ , &c. harumque differentias  $C, C_2, C_3, C_4, C_5, C_6, C_7$ , &c. harumque differentias  $D, D_2, D_3, D_4, D_5, D_6$ , &c. harumque differentias  $E, E_2, E_3, E_4, E_5$ , &c. harumque  $F, F_2, F_3, F_4$ , &c. Et sic porro. Differentiæ autem colligi debent auferendo

ferendo priores semper de posterioribus. Hoc est ponendo  $B = A_2 - A$ ,  $B_2 = A_3 - A_2$ ,  $B_3 = A_4 - A_3$ ,  $B_4 = A_5 - A_4$ ,  $B_5 = A_6 - A_5$ , &c. Tum  $C = B_2 - B$ ,  $C_2 = B_3 - B_2$ ,  $C_3 = B_4 - B_3$ ,  $C_4 = B_5 - B_4$ , &c. deinde  $D = C_2 - C$ ,  $D_2 = C_3 - C_2$ ,  $D_3 = C_4 - C_3$ , &c. Et similiter sunt omnes differentiae sequentes colligendae. Vel sint  $\alpha, \beta, \gamma, \delta, \epsilon, \zeta, \eta$ , &c. aequales  $A, A_2, A_3, A_4, A_5, A_6, A_7$ , &c. Eritque  $A = \alpha$ ,  $B = \beta - \alpha$ ,  $C = \gamma - 2\beta + \alpha$ ,  $D = \delta - 3\gamma + 3\beta - \alpha$ ,  $E = \epsilon - 4\delta + 6\gamma - 4\beta + \alpha$ ,  $F = \zeta - 5\epsilon + 10\delta - 10\gamma + 5\beta - \alpha$ ,  $G = \eta - 6\zeta + 15\epsilon - 20\delta + 15\gamma - 6\beta + \alpha$ , &c. In hisce valoribus numerales Coefficientes ipsorum  $\alpha, \beta, \gamma, \delta, \epsilon$  &c. generantur ut in dignitatibus integris Binomii  $1 - z$ ,  $1 - z^1$ ,  $1 - z^2$ ,  $1 - z^3$ ,  $1 - z^4$ , &c. Scribendo numeros 1, 2, 3, 4, 5, &c. in Serie  $1 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} \times$  &c. successive pro  $n$ . Sit jam  $P$  quaelibet Ordinata reliquis intermedia, &  $AP$  ejus distantia ab Ordinata prima  $A$  appelletur  $z$ , tum erit

$$P \mathcal{Q} = A +$$

$$B \times \frac{z}{1} +$$

$$C \times \frac{z}{1} \times \frac{z-1}{2} +$$

$$D \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} +$$

$$E \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} \times \frac{z-3}{4} +$$

$$F \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} \times \frac{z-3}{4} \times \frac{z-4}{5} +$$

$$G \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} \times \frac{z-3}{4} \times \frac{z-4}{5} \times \frac{z-5}{6} + \&c.$$

Adeoque

Adeoque signum ipsius  $z$  mutandum est, quando  $P \mathcal{Q}$  cadit ad alteras partes Ordinatae primæ, ut  $p q$ .

### Casus Secundus.

Sit jam  $A_5$  Ordinata in medio omnium; pone  $A = B_4 + B_5$ ,  $B = D_3 + D_4$ ,  $C = F_2 + F_3$ ,  $D = H + H_2$ , &c. &  $a = C_4$ ,  $b = E_3$ ,  $c = G_2$ ,  $d = I$ , &c. id est, si sint  $A_6 = \alpha$ ,  $A_7 = \beta$ ,  $A_8 = \gamma$ ,  $A_9 = \delta$ , &c.  $A_4 = \kappa$ ,  $A_3 = \lambda$ ,  $A_2 = \mu$ ,  $A = \nu$ , &c. Pone  $A = \alpha - \kappa$ ,  $B = \beta - 2\alpha + 2\kappa - \lambda$ ,  $C = \gamma - 4\beta + 5\alpha - 5\kappa + 4\lambda - \mu$ ,  $D = \delta - 6\gamma + 14\beta - 14\alpha + 14\kappa - 14\lambda + 6\mu - \nu$ , &c.  $a = \alpha - 2A_5 + \kappa$ ,  $b = \beta - 4\alpha + 6A_5 - 4\kappa + \lambda$ ,  $c = \gamma - 6\beta + 15\alpha - 20A_5 + 15\kappa - 6\lambda + \mu$ ,  $d = \delta - 8\gamma + 28\beta - 56\alpha + 70A_5 - 56\kappa + 28\lambda - 8\mu + \nu$ , &c. Et dicatur  $A_5 P$ ,  $z$ , tum erit

$$\begin{aligned}
 P \mathcal{Q} = A_5 + & \frac{Az + azz}{1.2} + \\
 & \frac{2Bz + bzz}{1.2} \times \frac{zz-1}{3.4} + \\
 & \frac{3Cz + czz}{1.2} \times \frac{zz-1}{3.4} \times \frac{zz-4}{5.6} + \\
 & \frac{4Dz + dzz}{1.2} \times \frac{zz-1}{3.4} \times \frac{zz-4}{5.6} \times \frac{zz-9}{7.8} + \\
 & \frac{5Ez + ezz}{1.2} \times \frac{zz-1}{3.4} \times \frac{zz-4}{5.6} \times \frac{zz-9}{7.8} \times \frac{zz-16}{9.10} + \\
 & \text{\&c.}
 \end{aligned}$$

### Casus Tertius.

Sint jam  $A_4$ ,  $A_5$ , Ordinatae duæ in medio omnium:  
Pone  $A = \frac{A_4 + A_5}{2}$ ,  $B = \frac{C_3 + C_4}{2}$ ,  $C = \frac{E_2 + E_3}{2}$ ,  $D =$   
10 A
G + G\_2

$\frac{G + Gz}{2}$ , &c.  $a = B4$ ,  $b = D3$ ,  $c = F2$ ,  $d = H$ , &c.

Vel sint  $A5 = \alpha$ ,  $A6 = \beta$ ,  $A7 = \gamma$ ,  $A8 = \delta$ , &c.  
 $A4 = \kappa$ ,  $A3 = \lambda$ ,  $A2 = \mu$ ,  $A = \nu$ , &c. Deinde erunt  
 $2A = \alpha + \kappa$ ,  $2B = \beta - \alpha - \kappa + \lambda$ ,  $2C = \gamma - 3\beta$   
 $+ 2\alpha + 2\kappa - 3\lambda + \mu$ ,  $2D = \delta - 5\gamma + 9\beta - 5\alpha -$   
 $5\kappa + 9\lambda - 5\mu + \nu$ , &c. Et  $a = \alpha - \kappa$ ,  $b = \beta - 3\alpha +$   
 $3\kappa - \lambda$ ,  $c = \gamma - 5\beta + 10\alpha - 10\kappa + 5\lambda - \mu$ ,  $d =$   
 $\delta - 7\gamma + 21\beta - 35\alpha + 35\kappa - 21\lambda + 7\mu - \nu$ , &c.  
 Et sit  $O$  punctum medium inter  $A4$ ,  $A5$ , atque appel-  
 letur  $OP$ ,  $z$ ; eritque Ordinata

$$PQ = \frac{A + az}{4^0} +$$

$$\frac{3B + bz}{4^1} \times \frac{4zz - 1}{2 \cdot 3} +$$

$$\frac{5C + cz}{4^2} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} +$$

$$\frac{7D + dz}{4^3} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} \times \frac{4zz - 25}{6 \cdot 7} +$$

$$\frac{9E + ez}{4^4} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} \times \frac{4zz - 25}{6 \cdot 7} \times \frac{4zz - 49}{8 \cdot 9} + \&c.$$

In hisce duobus etiam casibus  $z$  est negativa, quando Ordinata  $PQ$  cadit ad alteras partes initii Abscissæ. Et in omnibus tribus casibus distantia communis Ordinatarum ponitur unitas.

Omnes tres casus demonstrantur facillime per calculum. In casu primo pro  $PQ$  scribo successive  $\alpha, \beta, \gamma, \delta, \epsilon$ , &c. & pro  $z$  interea  $0, 1, 2, 3, 4$ , &c. quæ sunt longitudines Abscissæ ordine sequentes; & proveniunt æquationes

$$\alpha = A, \beta = A + B, \gamma = A + 2B + C, \delta = A + 3B + 3C + D,$$

$$\epsilon = A + 4B + 6C + 4D + E, \&c.$$

$$\beta - \alpha$$

$$\beta - \alpha = B, \gamma - \beta = B + C, \delta - \gamma = B + 2C + D, \\ \varepsilon - \delta = B + 3C + 3D + E, \&c.$$

$$\gamma - 2\beta + \alpha = C, \delta - 2\gamma + \beta = C + D, \varepsilon - 2\delta + \gamma \\ = C + 2D + E, \&c.$$

$$\delta - 3\gamma + 3\beta - \alpha = D, \varepsilon - 3\delta + 3\gamma - \beta = D + E, \&c.$$

$$\varepsilon - 4\delta + 6\gamma - 4\beta + \alpha = E, \&c.$$

Hæ *Æquationes*, capiendò earum differentias, nullo labore resolvuntur, uti videre est. Et dant eosdem ipsorum *A, B, C, D, &c.* valores, qui antea positi sunt in solutione. Et ad eundem modum demonstrantur casus duo reliqui.

Harum trium serierum unaquæque converget ad valorem *Ordinatæ P Q*, ubi *Ordinatarum* datarum differentia sunt iustæ magnitudinis. At ubi non convergunt, aliæ artes adhibendæ sunt. Sed impræsentiarum de hujus Propositionis usu pauca adjiciamus.

Designent  $\alpha, \beta, \gamma, \delta, \varepsilon, \zeta, \eta, \theta, \kappa, \lambda$ , &c. terminos quoscunque æquidistantes, quorum differentia sunt perexiguæ; & relationes quas inter se obtinent definientur quamproxime per *Æquationes* sequentes, quæ oriuntur capiendò differentias & differentias differentiarum continuò, & ponendo eas æquales nihilo.

$$\alpha - \beta = 0$$

$$\alpha - 2\beta + \gamma = 0$$

$$\alpha - 3\beta + 3\gamma - \delta = 0$$

$$\alpha - 4\beta + 6\gamma - 4\delta + \varepsilon = 0$$

$$\alpha - 5\beta + 10\gamma - 10\delta + 5\varepsilon - \zeta = 0$$

$$\alpha - 6\beta + 15\gamma - 20\delta + 15\varepsilon - 6\zeta + \eta = 0$$

$$\alpha - 7\beta + 21\gamma - 35\delta + 35\varepsilon - 21\zeta + 7\eta - \theta = 0$$

$$\alpha - 8\beta + 28\gamma - 56\delta + 70\varepsilon - 56\zeta + 28\eta - 8\theta + \kappa = 0$$

$$\alpha - 9\beta + 36\gamma - 84\delta + 126\varepsilon - 126\zeta + 84\eta - 36\theta + 9\kappa - \lambda = 0.$$

&c.

Hæc



Hæc Tabula in usum reservanda est, ut consulatur quoties opus sit. Quod autem hæc Æquationes vel obtinent accurate, vel ad verum approximant, ubi differentię terminorum sunt parvæ, patet ex demonstracione casus primi Propositionis.

Assumatur quælibet Series  $\frac{1}{101}, \frac{1}{102}, \frac{1}{103}, \frac{1}{104}, \frac{1}{105}, \frac{1}{106}, \&c.$  Et quærat terminus qui stat proximus ante  $\frac{1}{101}$ : patet quod ille est  $\frac{1}{100}$ ; videamus ergo qualem hæc methodus exhibebit eundem. Repræsentet  $\alpha$  terminum quæsitum, eritque

|                                                                                                                                                                                                                                                                                            |                                                                                                        |                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\frac{1}{101} = \beta = 0099,0099,0099,0,$<br>$\frac{1}{102} = \gamma = 0098,0392,1568,7,$<br>$\frac{1}{103} = \delta = 0097,0873,7864,1,$<br>$\frac{1}{104} = \epsilon = 0096,1538,4615,4,$<br>$\frac{1}{105} = \zeta = 0095,2380,9523,8,$<br>$\frac{1}{106} = \eta = 0094,3396,2264,2.$ | $\left. \begin{array}{l} 1ma \\ 2da \\ 3tia \\ 4ta \\ 5ta \\ 6ta \end{array} \right\} \text{Æquatio.}$ | $\left. \begin{array}{l} 1ma \\ 2da \\ 3tia \\ 4ta \\ 5ta \\ 6ta \end{array} \right\} \text{dat } \alpha \left\{ \begin{array}{l} 0099,0099,0099,0, \\ 0099,9805,8629,3, \\ 0099,9994,3455,0, \\ 0099,9999,7824,8, \\ 0099,9999,9895,8, \\ 0099,9999,9993,1. \end{array} \right.$ |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Patet ergo quod hæc methodus continue approximât. Si terminorum differentię fuissent minores, valores accessissent citius ad verum, & contra tardius quando differentię sunt majores. Hinc si in Tabulis numericis desit terminus, potest is per hanc methodum inferi.

Hoc modo etiam prodeunt ipsissimæ Series Speciosæ, quæ per alias methodos prodire solent. Proponatur  $1 + zz^{-1}$  Ordinata Curvæ quadrandæ: Ea est prima in serie regulari  $1 + zz^{-1}, 1 + zz^0, 1 + zz^1, 1 + zz^2, 1 + zz^3, \&c.$  Ordinatarum, quæ omnes præter primam dant suas areas  $z, z + \frac{1}{2}z^3, z + \frac{1}{2}z^3 + \frac{1}{5}z^5, z + \frac{1}{2}z^3 + \frac{1}{5}z^5 + \frac{1}{7}z^7, \&c.$  constituentes novam seriem cujus primus terminus erit Area quæsitæ: quæ ideo invenietur ponendo pro eâ  $\alpha$ , & pro reliquis in suo Ordine  $\beta, \gamma, \delta, \epsilon, \&c.$  Prima Æquatio dat  $\alpha = z$ , secunda  $\alpha = z - \frac{1}{2}z^3$ , tertia  $\alpha = z - \frac{1}{2}z^3 + \frac{1}{5}z^5$ , quarta  $\alpha = z - \frac{1}{2}z^3 + \frac{1}{5}z^5 - \frac{1}{7}z^7, \&c.$

&c. Est ergo universim area quæsitæ  $z - \frac{1}{2}z^3 + \frac{1}{5}z^5 - \frac{1}{7}z^7 + \frac{1}{9}z^9 - \frac{1}{11}z^{11}$  &c. Estque hæc Series arcus ad Tangentem  $z$ , in circulo radium habente unitati æqualem. Eam invenit *Jacobus Gregorius* noster, & cum *Collinio* communicavit initio anni 1671. à quo, mediante *Ol denburgo* ad *Leibnitium* delata est.

Sit jam &c,  $e, d, c, b, a, P, \alpha, \beta, \gamma, \delta, \epsilon$ , &c. Series utrinque excurrrens in infinitum, ubi dantur omnes termini præter  $P$  in medio omnium. Sit  $A = \alpha + a$ ,  $B = \beta + b$ ,  $C = \gamma + c$ ,  $D = \delta + d$ ,  $E = \epsilon + e$ , &c. atque erit

$$\begin{aligned}
 P &= \frac{A}{2} + \\
 &\quad \frac{A-B}{6} + \\
 &\quad \frac{5A-8B+3C}{60} + \\
 &\quad \frac{7A-14B+9C-2D}{140} + \\
 &\quad \frac{42A-96B+81C-32D+5E}{1260} + \\
 &\quad \frac{66A-165B+165C-88D+25E-3F}{2772} + \\
 &\quad \frac{429A-1144B+1287C-832D+325E-72F+7G}{24024} + \&c.
 \end{aligned}$$

Investigatur hæc Series ex Æquationibus, excerpendo alternas in quibus numerus terminorum est impar. Nam earum differentiæ relinquent terminos in hac Serie; quæ itaque ad libitum produci potest.

Sit  $1+z|^{-1}$  Ordinata Hyperbolæ, & quærat Area ejus quæ jacet supra Abscissam  $z$ , quando ea evadit unitas. Hæc Ordinata est media in Serie Ordinatarum

sum, &c.  $\frac{1}{1+z}^{-5}, \frac{1}{1+z}^{-4}, \frac{1}{1+z}^{-3}, \frac{1}{1+z}^{-2}, \frac{1}{1+z}^{-1},$   
 $\frac{1}{1+z}^0, \frac{1}{1+z}^1, \frac{1}{1+z}^2, \frac{1}{1+z}^3$  &c. æquidistantium,  
hinc inde excurrente in infinitum. Adeoque Areae ab  
hisce Ordinariis genitæ constituent seriem consimilem,  
cujus medius terminus erit Area quæsitæ; quæ proinde  
obtrinebitur per Seriem modo expolitam. Quando  $z$  est  
unitas, ut in casu præsentæ, areae curvarum evadunt  
&c.  $\frac{15}{64}, \frac{7}{24}, \frac{3}{8}, \frac{1}{2},$  &  $1, \frac{3}{2}, \frac{7}{3}, \frac{15}{4},$  &c. Hinc est  $A = 1 +$   
 $\frac{7}{2} = \frac{9}{2}, B = \frac{3}{2} + \frac{3}{8} = \frac{15}{8}, C = \frac{7}{3} + \frac{7}{24} = \frac{31}{8}, D = \frac{15}{4} + \frac{15}{64} = \frac{255}{64},$   
&c. Hisce in Serie substitutis, prodit  $P$ , id est, area  
Hyperbolæ,  $\frac{3}{4} - \frac{3}{48} + \frac{3}{480} - \frac{3}{4480} +$  &c. id est,  $\frac{3}{4} -$   
 $\frac{A}{4 \cdot 3} - \frac{2B}{4 \cdot 5} - \frac{3C}{4 \cdot 7} - \frac{4D}{4 \cdot 9} - \frac{5E}{4 \cdot 11} -$  &c. Ubi jam  $A,$   
 $B, C D,$  &c. more *Newtoniano*, designant terminos in suo  
ordine ab initio. Calculum appono.

### TERMINI.

Affirmativi

Negativi.

|                              |                              |
|------------------------------|------------------------------|
| 7500,0000,0000,0000,0        | 0625,0000,0000,0000,0        |
| 62,5000,0000,0000,0          | 6,6964,2857,1428,5           |
| 7440,4761,9047,6             | 845,5086,5800,8              |
| 97,5586,9130,8               | 11,3818,4731,9               |
| 1,3390,4086,1                | 1585,7062,8                  |
| 188,7745,5                   | 22,5708,7                    |
| 2,7085,0                     | 3260,2                       |
| 393,4                        | 47,5                         |
| 5,7                          | 7                            |
| <hr/> +7563,2539,3930,7494,1 | <hr/> -0631,7821,3370,8041,1 |

Summam negativam subducens ab affirmativâ, habeo  
pro Area, id est, pro Logarithmo Hyperbolico Binarii,  
numerum 6931,4718,0559,9453.

Pro

Pro constructione Tabularum quarumvis numerica-  
rum percommoda est Series quæ sequitur. Designent  
&c.  $e, d, c, b, a, \alpha, \epsilon, \gamma, \delta, \varepsilon$ , &c. terminos alternos in  
Serie utrinque serpente in infinitum; Pone  $A = \alpha + a$ ,  
 $B = \epsilon + b$ ,  $C = \gamma + c$ ,  $D = \delta + d$ ,  $E = \varepsilon + e$ , &c.  
Et terminus inter  $\alpha$  &  $a$  erit

$$\begin{aligned} & \frac{A}{2} + \\ & \frac{1}{1} \times \frac{A-B}{2^4} + \\ & \frac{1 \cdot 3}{1 \cdot 2} \times \frac{2A-3B+C}{2^7} + \\ & \frac{1 \cdot 3 \cdot 5}{1 \cdot 2 \cdot 3} \times \frac{5A-9B+5C-D}{2^{10}} + \\ & \frac{1 \cdot 3 \cdot 5 \cdot 7}{1 \cdot 2 \cdot 3 \cdot 4} \times \frac{14A-28B+20C-7D+E}{2^{13}} + \\ & \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} \times \frac{42A-90B+75C-35D+9E-F}{2^{16}} + \\ & \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 \cdot 6} \times \frac{132A-297B+275C-154D+54E-11F+G}{2^{19}} + \\ & \text{\&c.} \end{aligned}$$

Hæc Series sequitur ex casu tertio Propositionis,  
ponendo  $z=0$ . Coefficientes numerales literarum sic  
producuntur; exempli gratiâ, in quarto termino coe-  
fficiens literæ penultimæ  $C$  est 5; pone  $5+1=n$ , &  
numeri qui proveniunt ex multiplicatione terminorum  
 $1 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} \times \text{\&c.}$  erunt 1, 6, 15, 20,  
&c. Horum differentiæ 5, 9, 5, sunt numeri quæsi-  
ti. Atque adeo Series ad libitum produci potest.

Datis Logarithmis numerorum 46, 48, 50, 52, 54,  
56, 58 & 60; invenire Logarithmum numeri 53, qui  
consistit in medio omnium. Pone  $l, 52 + l, 54 = A =$   
 $3,4483,9710,34$ ,  $l, 50 + l, 56 = B = 3,4471,5803,13$ .  
 $l, 48$

$l, 48 + l, 58 = C = 3,4446.6923.08$ ,  $l, 46 + l, 60 = D = 3,4409,0908,19$ . Hisce valoribus in Serie scriptis, primi quatuor termini dabunt  $1,7242,2586,96$  pro Logarithmo numeri 53. Et eadem ratione invenire licet quemvis alium intermedium.

In Constructione ergo Tabularum sufficit primo quærere aliquos terminos in debitis distantis nam reliqui possunt hoc modo inseri. Etenim continuo sunt intercalandi termini primo inventi usque dum perventum fuerit ad ultimos qui desiderantur. Hoc modo habebitur tota Tabula ex datis paucis terminis sub initio pro fundamento operationis. Sed non convenit ut termini quos primo quærimus, sint omnes per totam Tabulam æquidistantes; nam si omittimus alternos ubi eorum differentia est maxima, possumus alibi per saltum omittere duos, tres, viginti aut forte plures terminos. Numerus autem terminorum inter duos datos consistentium, qui omittuntur, debet semper esse aliquis sequentium 1, 3, 7, 15, 31, 63, &c. dummodo volumus inserere eos per hanc Seriem; hoc vero neutiquam incommodabit opus.

Possunt autem pro Praxi termini in unam summam colligi, ut factum vides in hac Tabella. Prima expressio est primus terminus; secunda est summa primi & secundi; tertia est summa primi, secundi & tertii: & sic porro.

$$\begin{array}{r|l}
 2 & A \\
 & \hline
 4 & 9A - B \\
 & \hline
 6 & 150A - 25B + 3C \\
 & \hline
 8 & 1225A - 245B + 49C - 5D \\
 & \hline
 10 & 39690A - 8820B + 2268C - 305D + 35E \\
 & \hline
 & 65536
 \end{array}$$

Sic

Sic datis aliquibus terminis alternis, intermedii confestim dabuntur per hæc expressiones, nullâ ratione habitâ naturæ Tabulæ particularis. Nam hæ regulæ sunt eædem in omnibus. Areæ curvarum sunt proxime æquales areis Parabolicæ figuræ quæ transit per extrema Ordinatarum suarum. Sed quoniam laboriosum nimis esset semper recurrere ad Parabolam, computavi Tabulam sequentem, quâ Areæ directæ exhibentur ex datis Ordinatis.

$$\begin{array}{r|l}
 1 & \frac{A}{1} R \\
 3 & \frac{A + 4B}{6} R \\
 5 & \frac{7A + 32B + 12C}{90} R \\
 7 & \frac{41A + 216B + 27C + 272D}{840} R \\
 9 & \frac{989A + 5888B - 928C + 10496D - 4540E}{28350} R \\
 11 & \frac{16067A + 106300B - 48525C + 272400D - 260550E + 427368F}{598752} R.
 \end{array}$$

Hic numerus Ordinatarum est impar,  $A$  est summa primæ & ultimæ,  $B$  secundæ & penultimæ,  $C$  tertiæ & antepenultimæ; & sic porro, usque dum deventum sit ad eam in medio omnium, quæ per ultimam literam in quâque expressione repræsentatur.  $R$  est basis seu pars Abscissæ inter primam & ultimam Ordinatam interceptæ. Expressiones sunt Areæ contentæ inter Curvam, basin & Ordinatæ hinc inde extremas. Tabulam pro pare numero Ordinatarum non apposui, quoniam Area cæteris paribus ex impare earum numero accuratius definitur.

Quæraturs area quæ generatur ab Ordinatâ  $\overline{1 + zz}^{-1}$  & jacet supra Abscissam  $z$  quando ea evadit unitas. In

10 B
1 + zz

$\sqrt{1+z z^{-1}}$ , pro  $z$  scribe  $\frac{0}{10}, \frac{1}{10}, \frac{2}{10}, \frac{3}{10}, \frac{4}{10}, \frac{5}{10}, \frac{6}{10}, \frac{7}{10}, \frac{8}{10}, \frac{9}{10}, \frac{10}{10}$ ; & prodibunt undecim Ordinatae  $A, \frac{100}{101}, \frac{25}{109}, \frac{100}{109}, \frac{25}{109}, \frac{4}{5}, \frac{25}{54}, \frac{100}{149}, \frac{25}{41}, \frac{100}{181}, \frac{1}{2}$ . Hinc est  $A = 1 + \frac{1}{2} = \frac{3}{2}$ ,  $B = \frac{100}{101} + \frac{100}{181} = \frac{28100}{18281}$ ,  $C = \frac{25}{109} + \frac{25}{109} = \frac{1675}{10669}$ ,  $D = \frac{100}{109} + \frac{100}{149} = \frac{25800}{16241}$ ,  $E = \frac{25}{39} + \frac{25}{34} = \frac{1575}{986}$ ,  $F = \frac{4}{5}$ . Hisce valoribus substitutis in ultimâ expressione, & unitate pro  $R$ , invenies aream esse 785398187. Justus est hic numerus in septimâ figurâ, in octavâ verum superans Binario.

Si undecim Ordinatae non dent aream satis exactam, erige plures; & concipe aream divisam esse in plures partes, quarum quamque seorsum quærens habebis pro lubitu justam.

Valor ipsius  $\sqrt{1+Q^n}$  exprimi potest per quancunque trium serierum sequentium.

$$\begin{aligned} \sqrt{1+Q^n} &= 1 + \\ &Q \times \frac{n}{1} + \\ &Q^2 \times \frac{n}{1} \times \frac{n-1}{2} + \\ &Q^3 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} + \\ &Q^4 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} + \\ &Q^5 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} + \&c. \end{aligned}$$

$$\begin{aligned} \text{Vel } \sqrt{1+Q^n} &= 1 + \\ &R \times \frac{n}{1} + \\ &R^2 \times \frac{n}{1} \times \frac{n+1}{2} + \\ &R^3 \times \frac{n}{1} \times \frac{n+1}{2} \times \frac{n+2}{3} + \end{aligned}$$

$R^4 \times$

( 1065 )

$$R^4 \times \frac{n}{1} \times \frac{n+1}{2} \times \frac{n+2}{3} \times \frac{n+3}{4} +$$

$$R^5 \times \frac{n}{1} \times \frac{n+1}{2} \times \frac{n+2}{3} \times \frac{n+3}{4} \times \frac{n+4}{5} + \&c.$$

posito scilicet  $R = \frac{1+Q}{Q}$ . Vel

$$\overline{1+Q}^n = 1 +$$

$$\frac{2+n+1 \times Q}{1+Q} \times Q \times \frac{n}{1.2} +$$

$$\frac{4+n+2 \times Q}{1+Q} \times Q^2 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} +$$

$$\frac{6+n+3 \times Q}{1+Q} \times Q^3 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} \times \frac{nn-4}{5.6} +$$

$$\frac{8+n+4 \times Q}{1+Q} \times Q^4 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} \times \frac{nn-4}{5.6} \times \frac{nn-9}{7.8} +$$

$$\frac{10+n+5 \times Q}{1+Q} \times Q^5 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} \times \frac{nn-4}{5.6} \times \frac{nn-9}{7.8} \times \frac{nn-16}{9.10}$$

+ &c.

Primæ duæ Series demonstrantur per Casum primum Propositionis Nam si  $\overline{1+Q}^0$ ,  $\overline{1+Q}^1$ ,  $\overline{1+Q}^2$ ,  $\overline{1+Q}^3$ ,  $\overline{1+Q}^4$ , &c. designent Ordinatas totidem æquidistantes in Parabolicâ figurâ. erit  $\overline{1+Q}^n$  ejusdem Ordinata, cujus distantia à  $\overline{1+Q}^0$  est  $n$ . Et sic prodit Series prima. At si in alia Parabola  $\overline{1+Q}^0$ ,  $\overline{1+Q}^{-1}$ ,  $\overline{1+Q}^{-2}$ ,  $\overline{1+Q}^{-3}$ ,  $\overline{1+Q}^{-4}$ , &c. sint æquidistantes Ordinatæ, erit  $\overline{1+Q}^n$  Ordinata in eadem, cujus distantia à  $\overline{1+Q}^0$  est  $-n$ ; sic proveniet Series secunda Sit jam in tertia Parabola &c.  $\overline{1+Q}^{-4}$ ,  $\overline{1+Q}^{-3}$ ,  $\overline{1+Q}^{-2}$ ,  $\overline{1+Q}^{-1}$ ,  $\overline{1+Q}^0$ ,  $\overline{1+Q}^1$ ,  $\overline{1+Q}^2$ ,  $\overline{1+Q}^3$ ,  $\overline{1+Q}^4$ , &c. Series Ordinatarum



æquidistantium hinc inde progrediens in infinitum, eritque in eadem  $1 + 2^n$  Ordinata, distantia  $n$  à termino medio  $1 + 2^0$  remota. Et sic provenit Series tertia per Casum Secundum Propositionis. Prima abruptit quando est  $n$  integer & affirmativus, secunda quando est  $n$  integer & negativus, & tertia in casu utroque abruptit. Per harum quamque radices numerales commodè evolvuntur in Series. Tertia reliquis multo citius convergit: ejus terminus secundus adhiberi potest pro correctione, ubi fit extractio per repetitionem calculi.

*Halleius* in sua methodo construendi Logarithmos, ex prima harum serierum demonstrat Seriem *Mercatoris* pro Quadratura Hyperbolæ. Sit ejus Ordinata  $1 + z|^{-1}$ , vel  $1 + z|^{n-1}$ , existente  $n$  numero infinite parvo; unde per methodos Quadrandi, area quæ jacet supra Abscissam  $z$ , id est, Logarithmus numeri  $1 + z$ , erit  $\frac{1 - z|^{n-1}}{n}$ . Est vero per primam Seriem  $1 + z|^n = 1 + \frac{n}{1}z + \frac{n}{1} \times \frac{n-1}{2} z^2 + \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} z^3 + \&c.$  adeoque in casu præfente, ubi est  $n$  infinite parvus, est  $1 + z|^n = 1 + \frac{n}{1}z - \frac{n}{2}z^2 + \frac{n}{3}z^3 - \frac{n}{4}z^4 \&c.$  quo substituto in valore areæ, ea prodit  $z - \frac{1}{2}z^2 + \frac{1}{3}z^3 - \frac{1}{4}z^4 + \frac{1}{5}z^5 - \&c.$  quæ est Series *Mercatoris*.

Similiter per Seriem secundam prodit hæc regula; Sit datus numerus  $1 + z$ , pone  $R = \frac{z}{1+z}$ , eritque ejus Logarithmus  $R + \frac{1}{2}R^2 + \frac{1}{3}R^3 + \frac{1}{4}R^4 + \frac{1}{5}R^5 + \&c.$

Per Seriem tertiam provenit sequens regula. Sit quilibet numerus  $R$ , pone  $z = \frac{R-1}{2R}$ , eritque ejus Logarithmus

garithmus  $\frac{RR-1}{2R} = \frac{1}{2} Az - \frac{2}{3} Bz - \frac{2}{7} Cz - \frac{2}{11} Dz - \frac{2}{15} Ez$   
 — &c. Ubi  $A, B, C, D, E$ , &c. more *Newtoniano* designant terminos Seriei sicut ab initio. Hæc Series, ut ea ex qua deducitur, reliquis duabus multis vicibus celebrius approximatur: estque eadem generalius expressa quam, ex fundamento haud absimili, pro inventione Logarithmi Binarii prius dedimus.

*Methodus inveniendi valores Serierum Arithmeticarum utcumque tarde convergentium.*

In aliquibus Seriebus summa terminorum haberi nequit nisi ad paucissima figurarum loca, dummodo præter simplicem eorum additionem aliæ artes non adhibeantur. Proponatur jam Series quælibet cujus termini omnes iisdem signis afficiuntur, & quorum proximi continue tendunt esse inter se æquales; quales sunt sequentes  $\frac{1}{1 \cdot 2} + \frac{1}{3 \cdot 4} + \frac{1}{5 \cdot 6} + \frac{1}{7 \cdot 8} + \&c. 1 + \frac{1}{4} + \frac{1}{9} + \frac{1}{16} + \frac{1}{25} + \&c.$  Collige summam aliquot terminorum sub initio, ii proxime addendi sint  $\alpha, \beta, \gamma, \delta, \epsilon, \zeta$ , &c. In numeris proximis sit  $r = \frac{\alpha\gamma - \beta\beta}{\alpha\beta - 2\alpha\gamma + \beta\gamma}$ , & quantitatum  $\alpha \times \frac{\alpha + r\beta}{\alpha - \beta}$ ,  $\alpha + \beta \times \frac{\beta + r\gamma}{\beta - \gamma}$ ,  $\alpha + \beta + \gamma \times \frac{\gamma + r\delta}{\gamma - \delta}$ ,  $\alpha + \beta + \gamma + \delta \times \frac{\delta + r\epsilon}{\delta - \epsilon}$ ,  $\alpha + \beta + \gamma + \delta + \epsilon \times \frac{\epsilon + r\zeta}{\epsilon - \zeta}$ , &c. differentiarum sint  $a, b, c, d, e$ , &c. Deinde in numeris proximis sit  $s = \frac{ac - bb}{ab - 2ac + bc}$ , & ipsorum  $a \times \frac{a + sb}{a - b}$ ,  $a + b \times \frac{b + sc}{b - c}$ ,  $a + b + c \times \frac{c + sd}{c - d}$ ,  $a + b + c + d \times \frac{d + se}{d - e}$ , &c. differentiarum sint  $A, B, C, D$ , &c. & sit  $t = \frac{AC - BB}{AB - 2AC + BC}$ : atque sic procede



num,  $q$  secundum,  $r$  tertium, & rectangulum  $\frac{p+r}{2} \times q$  non sit majus  $pr$ , valor Seriei erit infinite magnus: at magnitudinis semper finitæ ubi accidit contrarium. Potest hæc regula nonnunquam fallere, ubi termini  $p$ ,  $q$ ,  $r$  parum distant ab initio Seriei, at si consistent inter eos ab initio aliquantum remotos, evadet regula certissima.

Ad alia Serierum genera debent aliæ regulæ adhiberi. Sit Series regularium Polygonorum Circulo Inscriptorum, existente Radio unitate.

$$\begin{aligned} H &= 2,0000,0000,0000,000 | 4 \\ G &= 2,8284,2712,4746,190 | 8 \\ F &= 3,0614,6745,8920,718 | 16 \\ E &= 3,1214,4515,2258,051 | 32 \\ D &= 3,1365,4849,0545,938 | 64 \\ C &= 3,1403,3115,6954,752 | 128 \\ B &= 3,1412,7725,0932,772 | 256 \\ A &= 3,1415,1380,1144,299 | 512 \end{aligned}$$

Dicatur jam ultimum Polygonum  $A$ , penultimum  $B$ , antepenultimum  $C$ , & reliqua in suo ordine retrorsum  $D$ ,  $E$ ,  $F$ , &c. atque area Circuli quæsitæ erit  $A + \frac{A-B}{3}$

$$+ \frac{4A-5B+C}{3 \cdot 15} + \frac{64A-84B+21C-D}{3 \cdot 15 \cdot 63} + \dots$$

$$\frac{4096A-5440B+1428C-85D+E}{3 \cdot 15 \cdot 63 \cdot 255} + \&c. \quad \text{Ubi si pro } A,$$

$B$ ,  $C$ ,  $D$ ,  $E$ , &c. scribantur proprii valores, primi quatuor termini dabunt 3,1415,9265,3589,790 pro area Circuli. Hæc autem Series est generalis, ex natura Circuli nequaquam dependens: applicabilis est quotiescunque numerorum approximantium differentiæ priores sunt posteriorum quasi quadruplæ. Factores in Denominatoribus sunt dignitates integræ numeri 4 unitatibus minutæ:

numæ: quibus datis, coefficientes literarum in diversis terminis formantur ex multiplicatione continua numerorum 1.  $\frac{n}{3}$ ,  $\frac{n-3}{15}$ ,  $\frac{n-15}{63}$ ,  $\frac{n-63}{255}$ , &c. Ubi pro  $n$  substituendus est ultimus Factorum in Denominatore.

Ultima quantitatum  $x - 1$ ,  $2^{\frac{1}{2}}x - 2$ ,  $4^{\frac{1}{3}}x - 4$ ,  $8^{\frac{1}{4}}x - 8$ ,  $16^{\frac{1}{5}}x - 16$ , &c. æqualis est Logarithmo numeri  $x$ . Pro  $x$  scribe 2, & per repetitam extractionem radicis quadratæ exhibunt numeri

$$\begin{aligned} M &= 1,0000,0000,0000,0000. \\ L &= 8284,2712,4746,1901. \\ I &= 7568,2864,0010,8843. \\ H &= 7240,6186,1322,0613. \\ G &= 7083,8051,8838,6214. \\ F &= 7007,0875,6931,7337. \\ E &= 6969,1430,7308,8294. \\ D &= 6950,2734,2438,7611. \\ C &= 6940,8641,2851,8363. \\ B &= 6936,1658,4759,4014. \\ A &= 6933,8182,9699,9493. \end{aligned}$$

Dicatur ultimus numerorum  $A$ , penultimus  $B$ , & sic retro, atque Logarithmus quæsitus erit  $A + \frac{A-B}{1} + \frac{2A-3B+C}{1 \cdot 3} + \frac{8A-14B+7C-D}{1 \cdot 3 \cdot 7} + \frac{64A-120B+70C-15D+E}{1 \cdot 3 \cdot 7 \cdot 15} + \&c.$  Primi quinque termini dant 6931,4718,0559, 9457 pro Logarithmo Hyperbolico Binarii. Et quomodo hæc Series procedit in infinitum facile colligitur ex eo quod de priorè diximus: estque etiam universalis, proprietates Hyperbolæ minime respiciens.

Extenditur quoque Methodus hæcce Differentialis ad Resolutionem  $\mathcal{A}$ equationum & alia quamplurima quorum hic non fit mentio. Continetque fundamenta Serierum generalissima; ut in Reductione  $\mathcal{A}$ equationum Irrationalium & Fluxionalium brevi forsan monstrabo.

IV. *An account of some Experiments made on the 27th day of April, 1719. to find how much the Resistance of the Air retards falling Bodies. By J. T. Defaguliers, LL. D. & F. R. S.*

**I** Took 12 Balls (six of which were solid Leaden Globes of about 2 Inches Diameter; three hollow Glasß Balls of about 5 Inches Diameter; and three light Pastboard hollow Globes of about the same Diameter) and having carried them to the upper Gallery in the Lanthorn, on the Dome of *St. Paul's Church*, I caused them to fall down by two at a time, in the following manner;

First, a Leaden Ball and a Glasß Ball.

Secondly, a Leaden Ball and a Glasß Ball.

Thirdly, a Leaden Ball and a Glasß Ball.

Then I let fall in the same manner the three other Leaden Balls, each with a Pastboard Ball.

After that, having the Leaden and Pastboard Balls brought up again, I repeated the Experiment twice more with a Leaden and Pastboard Ball: then I made the Experiment twice more with a Pastboard Ball alone, to see how long it would be in falling.

Upon the whole it appeared that the Leaden Balls were a very little longer than  $4\frac{1}{2}$  Seconds in falling; the two largest of the Glasß Balls 6 Seconds, and the Pastboard Balls  $6\frac{1}{2}$  Seconds.

The height of the Gallery, from whence the Bodies fell, was 272 Foot above the Pavement of the Church (then cover'd with Boards) upon which they fell.

The times of the Falls were taken two ways above, *viz.* with a Wheel-Chronometer, which measures a  
10 C
small

small part of Time accurately, nearer than to a quarter of a Second (made and contriv'd by Mr. *George Graham*, an ingenious Clock-maker) and with an  $\frac{1}{2}$  Second Pendulum: And the differences of Time between the fall of the Leaden Balls and the other Balls were taken below by the President, *Martin Folkes* Esq; F.R.S. and another Person, who all agreed in their Observations of the Time, which they made each with an half Second Pendulum.

The following Table gives the Marks, Weights, and Diameters of the several Balls, in three Columns.

| <i>Leaden Balls</i>     | <i>Troy Weight.</i><br><i>l. oz. d.</i> | <i>Diameters in Inches</i><br><i>and Decimals.</i> |
|-------------------------|-----------------------------------------|----------------------------------------------------|
| 1c                      | 2 : 1 : $\frac{1}{2}$                   | 2 , 1                                              |
| 2c                      | 1 : 11 : 4                              | 1 , 99                                             |
| 3c                      | 1 : 11 : 12                             | 2 , 0                                              |
| 4c                      | 1 : 11 : 12                             | 2 , 0                                              |
| 5c                      | 1 : 11 : 12                             | 2 , 0                                              |
| 6c                      | 1 : 10 : 0                              | 1 , 98                                             |
| <i>Paftboard Balls.</i> |                                         |                                                    |
| A                       | 0 : 3 : 6                               | 5 , 5                                              |
| B                       | 0 : 1 : 14                              | 5 , 1                                              |
| C                       | 0 : 1 : 17                              | 5 , 1                                              |
| <i>Glafs Balls.</i>     |                                         |                                                    |
| D                       | 0 : 3 : 13 $\frac{1}{2}$                | 3 , 9                                              |
| E                       | 0 : 5 : 3 $\frac{1}{2}$                 | 5 , 42                                             |
| F                       | 0 : 6 : 0 $\frac{1}{2}$                 | 5 , 55                                             |

*N.B.* The Polar and Equatorial Diameters of the Glaſs Balls being different, I have ſet down a Mean Diameter for each of them; the true Diameters are thus, of D 4 & 3,8. of E 5, 6 and 5,25. of F 5,7 & 5,4 Inches.

*The*

*The particular Experiments are as follows.*

Experiment I. Fall of 1c and D.

c fell by the Pendulum in  $4\frac{1}{2}''$ .

The Fall of D was so near it, that the Difference was not taken either above or below.

Experiments II. Fall of 2c and E.

2c fell by the Chronometer in  $5''$ , by the Pendulum in  $4\frac{1}{2}''$ .

Time of the fall of E not taken above.

The Difference taken below  $1\frac{3}{4}''$ .

Experiment III. Fall of 3c and F.

3c fell by Chronometer in  $4\frac{1}{2}''$ , by Pendulum in  $4\frac{1}{2}''$ .

F fell in Six Seconds.

Difference taken below was  $1\frac{1}{2}''$ .

Experiment IV. Fall of 4c and A.

4c fell by Chronometer in  $4\frac{1}{2}''$ , by Pendulum in  $4\frac{1}{2}''$ .

A fell in  $6\frac{1}{2}$  Seconds.

Difference taken below =  $2''$ .

Experiment V. Fall of 5c and B.

We made no Observation above nor below.

Experiment VI. Fall of 6c and C.

6c fell by Chronometer in  $4\frac{3}{4}''$ , by Pendulum in  $4\frac{3}{4}''$ .

C not taken above.

Difference below =  $2\frac{1}{9}''$ .

Experiment VII. Fall 1 c and B.

1 c fell by Chronometer in  $4\frac{3}{4}''$ , by Pendulum in  $4\frac{3}{4}''$ .

B not taken above.

Difference taken below  $2\frac{3}{8}''$

10 C 2

Experi-



Experiment VIII. Fall of *5c* and *A*.

*5c* fell by Pendulum in  $4\frac{3}{4}''$ .

*A* fell foul and so was not observ'd at all.

Difference taken below  $2''$ .

Experiment IX. Fall of *B* alone.

by the Chronometer in  $6\frac{1}{2}''$ , by the Pendulum in  $6\frac{1}{2}''$ .

Experiment X. Fall of *C* alone

by the Chronometer in  $6\frac{1}{2}''$  by the Pendulum in  $6\frac{1}{2}''$ .

By *Galileo's* Theory the Lead, which was  $4\frac{1}{2}''$  in falling, must fall 4 Foot the first  $\frac{1}{2}''$ , or 16 Feet the first Second, which amounts to 324 Feet in  $4\frac{1}{2}''$ . But as the Sound of the Ball (as it struck the Bottom) by which we reckon'd our Time, had 272 Feet to move, we must abate a  $\frac{1}{4}$  of a Second nearly, (supposing Sound to move one Mile in  $4\frac{1}{2}''$ ) which will take away 35 Feet, that the Body must have fallen in the last  $\frac{1}{4}$  of a Second, and reduce the number of Feet to 289 : so that the Lead will have only fallen 17 Feet short of the Theory, which must be attributed to the Resistance of the Air.

The large Glass Ball in the 6 Seconds of its Fall, wou'd in a *Vacuum* go thro' 576 Feet : but taking away the last  $\frac{1}{4}$  of a Second or 47 Feet, for motion of Sound, it must only fall 529 Feet in *Vacuo*. Now since it fell but 272, there have been 257 Feet taken off from the Fall by the Air's Resistance.

Likewise the Pastboard Ball in  $6\frac{1}{2}$  Seconds must have fallen 676 Feet : but deducting the last quarter of a Second or 51 Feet for the motion of the Sound, there remains only 625 Feet for its fall in *Vacuo*. But as it fell only 272 Feet, we must allow a Retardment of 353 Feet for the Resistance of the Air.

As

At a mean we may call the weight of the Glass Ball 5 oz. *Troy*, and its Diameter 5 Inches and  $\frac{1}{2}$ ; and the weight of the Pastboard Ball 2 Ounces *Troy*, and a little more than 5 Inches Diameter.

The Lead Balls all fell within near a Foot of one another, and made an impression in the Boards of about  $\frac{1}{2}$  of their Depth.

The Barometer stood at 30, 1 Inches, and the Mercury was very Convex, and therefore inclined to rise still.

*A further Account of Experiments made for the same purpose, upon the 27th Day of July last. By the same.*

**H**AVING found by our former Experiments, that thin Glass Balls, and even Balls of pasted Paper, were too heavy to make so considerable a Difference between the time of their Fall and the fall of Lead Ball, that it might be easily Observ'd; I contriv'd a way to make dried Hogs Bladders perfectly round, by blowing them (when moist) within a strong Spherical Box of *Lignum Vita*, and letting them dry in the said Box before I took them out: which I did by opening the Box that screw'd in the middle, and had a hole in the Pole of one of its Hemispheres to let the Bladder pass thro', in order to tie it after blowing; and some few small holes all over the Box, that in blowing no Air might be confin'd between the inside of the Box and the Bladder, so as to hinder it from putting on a Spherical Figure. Besides I took off the ends of the *Ureters*, the Fat and a great deal of the upper

upper Coats of the Bladders, before I blowed them in the Box, to render them still lighter.

The Bladders I used were some of the thinnest I cou'd find ready blown at a *Druggists*, which I moistened in Water, taking care to leave none in the inside. I chose those rather than Green ones, which in drying wou'd have stuck so fast to the inside of the Box, that it wou'd scarce have been possible to have got them out without tearing.

Having prepared five Bladders in the manner aforesaid, (which I have described the more fully to direct any body else that shou'd be willing to try the like Experiments) I took them up to the upper Gallery in the Lantern on the Top of the *Cupola* in *St. Pauls Church*; and there by a Contrivance, which I shall just now describe, I let them fall by one at a time, together with a Leaden Ball of about 2 Inches Diameter, and weighing 2 *l. Troy*: and I took notice of the time of the Fall of each Bladder, knowing by former Experiments that the Balls are about  $4\frac{1}{4}$  Seconds, or a little longer time, in falling the same Height, which is 272 Feet.

The following Table, consisting of five Columns, gives in the first, the Marks of the Bladders; in the next their Diameters; in the third their Weights in Grains *Troy*; in the fourth the times of their Fall in Second Minutes of time; and in the fifth, the difference of Time between the Falls of the Leads and of each Bladder, taken below by the *President*, *Dr. Halley*, *Dr. Jurin*, *Martin Folkes Esq*; and *Mr. George Graham* the Clock-maker. The Time was taken above with *Mr. Graham's Chronometer*, (formerly described); and below with the same Instrument, and three half Second Pendulums, all which agreed very well together.

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The Experiments having been made twice over, the Table is twice set down; and those Experiments in which the Bladders fell streight down, and the most regularly, have this Mark before them (\*).

| <i>Marks.</i> | <i>Diameters<br/>in Inches</i> | <i>Weight in<br/>Grains Troy</i> | <i>Time of the<br/>whole Fall</i> | <i>Diff. between the<br/>Lead and Bladder.</i> |
|---------------|--------------------------------|----------------------------------|-----------------------------------|------------------------------------------------|
| A             | 5,3                            | 128                              | 19 $\frac{3}{8}$ "                | 14 $\frac{1}{8}$ Seconds.                      |
| * B           | 5,193                          | 156                              | 17 $\frac{1}{4}$                  | 12 $\frac{3}{4}$                               |
| C             | 5,33                           | 137 $\frac{1}{2}$                | 18 $\frac{3}{4}$                  | 14 $\frac{5}{8}$                               |
| D             | 5,26                           | 97 $\frac{1}{2}$                 | 22 $\frac{1}{8}$                  | 17 $\frac{5}{8}$                               |
| * E           | 5,02                           | 99 $\frac{1}{8}$                 | 21 $\frac{5}{8}$                  | 17                                             |
| * A           |                                |                                  | 19"                               | 14 $\frac{1}{2}$                               |
| B             |                                |                                  | 18 $\frac{5}{8}$                  | 14 $\frac{1}{4}$                               |
| * C           |                                |                                  | 18 $\frac{3}{8}$                  | 14                                             |
| D             |                                |                                  | 24                                | 19 $\frac{1}{8}$                               |
| E             |                                |                                  | 21 $\frac{1}{4}$                  | 16 $\frac{5}{8}$                               |

The Diameters and Weights may be relied upon, being taken the Day that the Experiments were made, and the Day after; but the Diameters and Weights taken 10 Days before, not agreeing with these, I have left them out. For the Bladders by drying had lost of their Weight, and altered their Diameters.

As the Necks of the Bladders in drying shrink, so as to open a little, they must be blown before each Experiment. And for the manner of letting them fall exactly in the same Instant of time, it is described by Figure II, in which

A, A, A A, is the Hole through which the Bodies fell: 1, 2, is a Board laid over the Hole. G, D, D is another Board fixt to the first Board by the two Wood-Screws D, D, with a Pulley G at the other end of it, over the Hole. W is a two Pound Ball of Lead fastned

fastned to a strong Thread, which going over the Pulley is stretched horizontally from G to the Nails F; to which it is fastned, so as to be about a quarter of an Inch above the Board.

B is one of the Bladders, hanging with the Neck or heaviest part downwards, by means of a Loop of fine Thread as E H, which goes over the Horizontal Thread G E F. Now when with a pair of Scissars the Thread of the Lead (which in all is but one Foot long) is cut just at E, before the Loop of the Bladder, the Lead pulling away the String the Loop of the Bladder slips off the remaining Thread F E, and begins to fall exactly in the same Instant as the Lead: But if the Thread should be cut between E and F, as the Lead falls its Thread might give the Bladder an oblique Direction.

He that observes the time either with a Pendulum or Chronometer may take it very exactly, by seeing the motion of the Scissars as they cut the Thread.

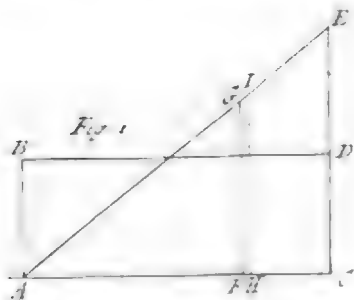
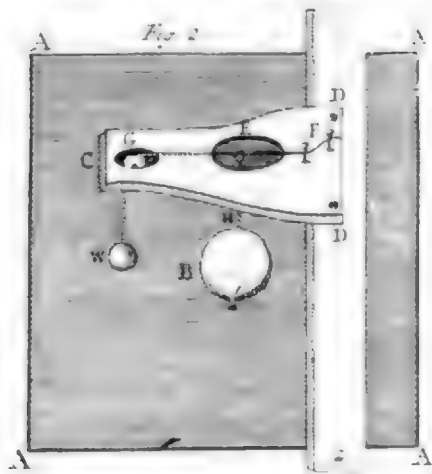
*N. B.* As the Diameters of the Bladders were taken by wrapping a Thread twice round them, and something must be allowed for the thickness of the Thread; I have here under set down the Diameters of the Bladders, as corrected by that Allowance. *Viz.* A 5,28 Inches; B 5,19; C 5,30; D  $5\frac{1}{4}$ ; and E just 5 Inches in Diameter.

The Bladder E was rough, with several Wrinkles and inequalities, which made it be longer in falling than it ought to have been, according to its Diameter and Weight.

A Pail of Water thrown down met with such a Resistance in falling 272 Foot thro' the Air, that it was all turn'd into Drops like Rain.

*F I N I S.*

**E**RRATA. *Phil. Transf.* N°. 357. Page 848. l. 22. lege ab *b* 11' 32". N°. 359. p. 932. l. 17. lege  $\frac{1}{2}$  0", i. p. 937. l. 5, 6. lege restituatur. Et Systole Arteriarum cum Cordis Diastole duratione convenit. N°. 361. p. 1005. l. 16. read, *proof of the falsity of the Opinion.*



# PHILOSOPHICAL TRANSACTIONS.

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For the Months of Novemb. and Decemb. 1719.

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- I. *A Letter of Mr. Joseph Williamson Watchmaker, to the Publisher, wherein he asserts his Right to the curious and useful Invention of making Clocks to keep Time with the Suns Apparent Motion.*

**H**AVING been inform'd of a *French Book* lately published, wherein the Author speaks of making Clocks to agree with the Sun's apparent Motion; and supposeth that it was a thing never thought of by any before himself: I was therefore willin' by the advice of some of my Friends, to write this short Account of what I have performed in that matter my self.

And in the first place I must take notice of the Copy of a Letter in this Book, wrote by one *P. Kresa* a Jesuit, to one Mr *Williamson*, Clockmaker to his *Imperial Majesty*; of a Clock found in the late King *Charles the Second* of Spain's Cabinet, about the Year 1690 or 1700: which sheweth both equal and apparent Time according to the Tables of Equation; and which went 400 Days without winding up. This I am well satisfied is a Clock of my own making; for about six Years before that time, I made one for Mr. *Daniel Quare*, for whom I then wrought mostly, which agrees with the Description he gives of it, and went 400 Days as he saith. This Clock Mr. *Daniel Quare* sold, soon after it was made, to go to the said King *Charles the Second* of Spain: and it was made so that if the *Pendulum* was adjusted to the Sun's mean Motion, the Hands would shew Equal Time on two fixed Circles, on one the Hour, and on the other the Minute. But there were other two moveable Circles of the same kind, that  
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moved forwards and backwards, as the time of the Year required; on which the same Hands shewed Apparent Time likewise, according to the Equation Tables. This Method the Author owns he knew of, and applyed the same Motion to Pocket Watches 12. or 14 Years ago, which I confels I never did; being well satisfied that Watches with Springs and Ballances are very unfit to shew the minute difference, as it increaseth and decreaseth, between equal and apparent Time.

Soon after this Clock was sent to *Spain*, I made others for Mr. *Quare* which shewed Apparent Time by lengthning and shortning the *Pendulum*, in lifting it up and letting it down again, by a Rowler somewhat in the form of an *Ellipsis*, through a slit in a piece of Brass, which the Spring at the Top of the Pendulum went through. By this means every vibration of the *Pendulum* would agree to a Second of Time of the Suns apparent Motion; that Rowler which lifted up the *Pendulum*, and let it down again, being continually moving about all the Year; so that it may seem very strange that this Author never heard of it, so many Years after they were made: For one of those, and not the first, made with the rising and setting of the Sun, Mr. *Quare* sold to the late King *William*, and it was set up at *Hampton-Court* in his Life time, where it hath been ever since. This contrivance of lengthning and shortning the *Pendulum*, I thought of several Years before I made any of them. Since then I have made others for Mr. *Quare* likewise, which shewed the difference between equal and apparent Time according to the Equation Tables, by a Hand moving both ways from the top of a Circle; on one side shewing how much a Clock keeping equal Time ought to be faster than the Sun, on the other side how much slower.

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But these Clocks that I then made to agree with the Sun's Apparent Time, were done according to the Equation Tables, which I found not to agree very exactly with the Sun's apparent Motion: neither can any other be made to keep equal Time that will gain and lose all the Year agreeable to the said Tables: for though the Tables themselves may be true, yet some difference in Motion does proceed, in both sorts of Clocks, from Cold and Heat altering the length of their *Pendulums*. This difference by some Observations I have made, I suppose to be about the  $\frac{1}{100}$  part of an Inch in the length of a *Pendulum* vibrating Seconds, which will alter the Motion of the Clock about 12 Seconds in 24 Hours. But to make my Clocks made for keeping Apparent Time to go as exact as possible, I made a Table my self by Observation: For observing the Sun, as often as it was to be seen, when it came on the Meridian, for several Years together, always setting down the Difference between its coming to the Meridian and the Time by a Clock I had adjusted as well as I could to equal Time, and always taking notice how much my Equal-Time Clock gain'd or lost at the end of every Year, I compleated my Table in the Year 1711. Since then I have made a considerable many of these Clocks, several of which I sold to Persons of great Note and Ingenuity; and in particular one I made about five or six Years since for the Right Honourable the Lord *Parker*, at present Lord High Chancellor of *Great Britain*; and all of them have given good content to those that bought them. So that I think I may justly claim the greatest right to this contrivance of making Clocks to go with Apparent Time; and I have never yet heard of any such Clock sold in *England*, but what was of my own making, though I have made of them so long.

II. *An Account of some new Experiments, relating to the Action of Glass Tubes upon Water and Quicksilver.* By James Jurin, M. D. Reg. Soc. & Coll. Med. Lond. Soc.

IN a \* Discourse formerly presented to the *Royal Society*, I maintain'd, that the Suspension of Water in a Capillary Tube was owing to the Attraction of a small annular surface on the inside of the Tube, which touch'd the upper part of the Water. Among the several Experiments made use of to prove this Assertion, was that of a Glass Funnel of several Inches Diameter, having its small end drawn out into a very fine Tube, which Funnel being inverted and fill'd with Water, the whole quantity of Water therein contain'd was sustain'd above the Level by the Attraction of that narrow *Annulus* of Glass, with which the upper surface of the Water was in contact.

Soon after that Discourse was printed, came out a Book publish'd by a very Learned and Ingenious Member of this Society, in which that Experiment was accounted for in the following Manner.

*If there be a Funnel, as ABC, Fig. 1. full of Water, and whose wide end stands in a Vessel of Water as BC; and the Top of the Funnel A ends in a Capillary Tube open at A, the whole Water will be sustain'd: the Pillar Aa by the Attraction of the Circle of Glass within the Tube immediately above it; and all the rest of the Pillars of Water, as Ff, Dd, Ee, Gg, &c. in some measure by the Attraction of the parts of the Glass above them, as F,*

\* *Philos. Transact.* N<sup>o</sup>. 355.

*D, E, G: And hat the small Pillars or Threads of Water Dd, and Ee, do not slide down to Ff, and Gg, and so go quite down, seems to be owing to their Cohesion with the Pillar Aa, which is sustain'd by the Capillary Tube A: For if you break off the said Tube at DE, the whole Water will presently sink down.*

As this Solution was very different from what I had before given, and the Reputation of that Gentleman, whose great Knowledge in Experimental Philosophy is generally known, was sufficient to give weight to any of his Opinions, I thought my self under an Obligation to examine his account of the Experiment, in order either to demonstrate its insufficiency, or to retract my own Solution. Accordingly at the next meeting of the Society, I produced the following Experiment.

The Funnel, A F G B C, *Fig 2.* whose lower part B C F G, was Cylindrical to a considerable height, and whose top was drawn out into a fine Tube at A, being fill'd with Water to the height B F, so that the surface of the Water F G, did not reach to the arch'd part of the Funnel, I touch'd the end A with a wetted Finger, whereby a small quantity of Water being insinuated into the Capillary Tube at A, the Water contain'd in the Funnel was suspended above the Level of the Water in the Cistern D E, as in the former Experiment.

In this Experiment it is manifest, that the little Columns, into which we may suppose the Cylinder of Water, F G B C, to be divided, are no way sustain'd by the Attraction of the arch'd part of the Glass above them, since they have no contact with it. Nor is there any such middle Pillar of Water, which, by its contact with the Tube at top. is both sustain'd it self, and helps to support the Pillars about it. Upon the  
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supposition of which two Particulars that Gentleman's Solution was founded.

This Experiment may be thus accounted for. The Cylinder of Water F G B C, by its weight balances a part of the pressure of the Atmosphere, which is incumbent on the Water in the Cistern, and endeavours to force that Cylinder upwards. The rest of that pressure is balanced by the Spring of the Air, A F G, which is included between the Cylinder of Water F G B C, and the little Column of Water in the Capillary A. But, as this Air by its Spring presses equally every way, it must balance as much of the pressure of the Atmosphere upon the little Column of Water at A, as it does of that upon the Water in the Cistern. The remainder of the pressure of the Atmosphere upon the Column of Water at A is sustain'd by the force with which that Column adheres to the Capillary Tube, which therefore does exactly balance the weight of the Cylinder of Water F G B C, and is the real, though not the immediate, cause of its Suspension.

The experiment succeeds in the same manner when a Column of Quicksilver is raised into the Funnel, instead of the Column of Water F G B C, the top of the Tube being touch'd with a wet Finger as before. But then the height of the Quicksilver in the Funnel must be as much less than that of the Water, as its Specific Gravity is greater.

I proceed now to acquit my self of a Promise I made in the Discourse abovemention'd, of examining whether the Experiments therein contain'd would succeed *in Vacuo*; and whether Water could be suspended in a wide Tube by means of a Capillary at Top, at a greater height, than what it can be rais'd to by the Pressure of the Atmosphere.

In order to this, I boil'd some Water, and afterwards purged it of its Air by means of the Air-pump; which being done, those Experiments all succeeded in the exhausted Receiver, in the same manner as in the open Air.

The 13<sup>th</sup> Experiment in particular was made with a Tube of about 35 Inches in length, and a quarter of an Inch Diameter, the top of it being drawn out into a fine Capillary. Which being fill'd with Water purged of its Air, as before mention'd, the whole quantity continued suspended in the exhausted Receiver.

This plainly shews, that the success of that Experiment does not depend upon the Pressure of the Air, since the small quantity of Air left in the Receiver was by no means capable of sustaining the Water at so great a height, and consequently that the height, at which Water may be suspended in this manner, is not limited by that Pressure.

But here I must not omit taking notice of a considerable Difficulty, which presents it self to those who attentively consider this Experiment. In order to make which the better appear, it will be proper to observe what happens, when a simple Capillary Tube is fill'd with Water purged of Air, and inclos'd in the exhausted Receiver.

In this case the whole Column of Water contained in the Tube A C B, *Fig. 3d.* is suspended by the Attraction of the *Annulus* at the top of the Tube, A. And though that *Annulus* does not immediately act upon any part of the Water, except what is either contiguous to it, or so near as to be within the Sphere of its Attraction, which extends but to a very small distance; yet it is impossible, that any other part of the Water, as for instance that at C, should part from the Water above it and sink down, because its descent is oppos'd  
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by the attraction of the contiguous *Annulus* at C. For this, being equal to the upper *Annulus* at A, is capable of sustaining a Column of Water of the length AB, and consequently is more than sufficient for supporting the Column of Water below it, CB. From which it is plain, that no part of the Water contain'd in the Tube can possibly descend, unless the upper part, assisted by the weight of the Water below it, be sufficient to overcome the Attraction of the *Annulus* of Glass at A.

But in such a compound Tube as that made use of in our Experiment, *Fig. 4th* ACB, the case is very different, and it does not easily appear, why in a *Vacuum* any part of the Water in the wider part of the Tube, as for Example at C, should not leave that which is above it, and descend; since the *Annulus* at C is by much too wide to sustain a Column of Water of so great a length as CB,

The best answer I can give to this difficulty is, that the Cohesion between the Water contain'd in the Capillary and that below it, is sufficient to balance the weight of the Column suspended. But how far this Cohesion may depend upon the Pressure of a Medium subtile enough to penetrate the Receiver, is worthy of Consideration. For though such a Medium will pervade the Pores of the Water, as well as those of the Glass, yet it will act with its intire Pressure upon all the solid Particles, if I may so call them, of the surface of the Water in the Cistern; whereas so many of the solid Particles of the Water in the Tube, which happen to lie directly under the solid Particles of the Water above them, will thereby be secur'd from this Pressure; and consequently there will be a less Pressure of this Medium upon any surface of the Water in the Tube below the Capillary, than upon an equal surface of the Water in the Cistern. So that the Column of Water suspended  
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in the Tube may be sustain'd by the difference between those two Pressures. This Explication seems to be favour'd by the following Experiments, which may all be accounted for in the same manner, though I shall anon mention another Cause, which contributes to the Success of the first and second.

The first I shall mention, is the famous Experiment of the suspension of Mercury purged of Air, to the height of 70 or 75 Inches, in the *Torricellian Tube*, in the open Air. To which we may add the sustaining of Mercury likewise purged of Air within the exhausted Receiver, as related by that Learned and Successful Promoter of Natural Knowledge, *Monf. Papin*, in his *Continuation du Digesteur*. I forbear to mention the suspension of Water purged of Air, in the *Vacuum*, which he describes in the same Book; because there is little difference between that Experiment and our own abovementioned, the very top of the arched part of his Tube, which top we may suppose as small as we please, supplying the place of the fine Capillary at the top of our Tube. But we must not omit the Experiments made by the famous *Monf. Huygens*, and described by him in *Phil. Transact.* No. 86. of the cohering of polish'd Plates with a considerable force in the exhausted Receiver; as likewise of the running of Water and Mercury, when purged of Air, through a Siphon of unequal Legs in the *Vacuum*: All which he accounts for from the same Principle, and much in the same manner, as we have used for explaining the Experiment above.

As to the Existence of such a Medium, I shall content my self to refer to what has been said by our *Illustrious President* in the Queries at the latter end of the last Edition of his *Opticks*: and as I have lately had the Honour to entertain the Society with some Experiments upon Quicksilver, which were exactly the reverse



reverse of those made by Dr. *Taylor*, the late Mr. *Hawksbee* and my self, upon Water; by which I am now enabled to throw this whole affair into a little System by it self, I shall beg leave to lay it down in the following Propositions, the Proof of which is contain'd in the Experiments annext.

### PROPOSITION I.

*The Particles of Water attract one another.*

This, I think, is now universally acknowledged, and therefore needs no Demonstration; the Sphericity of the drops of Rain, and the running of two drops of Water into one another upon their contact, manifestly proving it.

### PROPOSITION II.

*The Particles of Quicksilver attract one another.*

This is likewise manifest from the Spherical Figure, into which a drop of Mercury forms it self upon a Table; and from two of them immediately running together, as soon as they come to touch.

### PROPOSITION III.

*Water is attracted by Glass.*

This plainly appears from all the Experiments, that we have shewn upon this Subject.

### PROPOSITION IV.

*Quicksilver is attracted by Glass.*

*Experiment I.* If a small Globule of Quicksilver be laid upon a clean Paper, and be touched with a piece of clean Glass; upon drawing the Glass gently away,

away, the Quicksilver will adhere to it, and be drawn away with it. And if the Glass be lifted up from the Paper, the Quicksilver will be taken up by it, in the same manner as a piece of Iron is drawn up by the Loadstone, and will stick to the Glass by a plain Surface of a considerable breadth, in proportion to the bulk of the drop, as manifestly appears by an ordinary Microscope. Then if the Glass be held a little obliquely, the drop of Mercury will roll slowly upon its Axis along the under side of the Glass, till it comes to the end, where it will be suspended as before.

*Exp. 2d.* If a pretty large drop of Mercury be laid upon a Paper, and two pieces of Glass be made to touch it, one on each side; upon drawing the Glasses gently from each other, the drop of Mercury will adhere to them both, and will be visibly drawn out from a globular to an oval Shape; the longer Axis passing through the middle of those Surfaces, in which the drop touches the Glasses.

## PROPOSITION V.

*The Particles of Water are more strongly attracted by Glasses, than by one another.*

This manifestly appears from the rising of Water in small Tubes above the Level. For when the Water begins to rise into a Capillary Tube, all the Particles of Water, which touch the small *Annulus* at the bottom of the Tube, must have quitted the contact of the other Water, and have risen contrary to their Gravity, to come into contact with the Glass. After the same manner the other Experiments of Dr. Taylor, Mr. Hawksbee and my self, upon this Subject, are easily explicable. For upon a careful Examination, it will be found  
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in them all, that some parts of the Water quit the contact of the other Water, and join themselves to the Glass.

### PROPOSITION VI.

*The Particles of Quicksilver are more strongly attracted by one another, than by Glass.*

*Exp I. Fig. 5.* If a small Tube as AB, open at both ends, be dipt into a Glass Vessel fill'd with Mercury, and be held close to the side of the Vessel, that the rise of the Mercury within it may appear; the Mercury will partly enter into the Tube, but will stand within it at some depth, as CE, below the Surface of the Quicksilver in the Vessel, CD; and this depth will always be reciprocally as the Diameter of the Tube.

In this Experiment a Column of Quicksilver of the height CE endeavours to force the Mercury higher into the Tube; and as Glass has been already prov'd to attract Quicksilver, the Attraction of the annular Surface on the inside of the Tube, which is contiguous to the upper part of the Mercury, will likewise conspire to farther its ascent. What opposes the ascent of the Quicksilver, is the Power, by which that part of it, which endeavours to rise into the Glass, is drawn back by the Attraction of the other Mercury, with which it is in contact laterally, and this does not only balance the Attraction of the Glass, but likewise the weight of the Column of Mercury of the height CE, and consequently this Attraction is considerably stronger than the Attraction of the Glass.

The cause therefore, that suspends the weight of the Column of Mercury CE, being the difference between the Attraction of the annular Surface of the Tube at E, and that of an equal Surface of the Quicksilver in the Cistern, from which the Mercury, that endeavours to

rise into the Tube, must recede, in order to unite it self to such an Annulus of the Glass, will always be proportional to that annular Surface, or to the Diameter of the Tube. And since the Column sustain'd must be proportional to the Cause that suspends it, that Column must likewise be as the Diameter of the Tube. But the Column suspended is as the Square of the Diameter of the Tube and the height  $CE$  conjointly; from which it follows, that the height  $CE$  must be as the Diameter of the Tube reciprocally, as it is found to be by Experiment.

The Experiment of the Ascent of Water above the Level in a Capillary Tube, is just the Reverse of this.

*Exp. II. Fig. 6.* Quicksilver being poured into the inverted Siphon  $ACB$ , one of whose Legs  $AC$  is narrower than the other  $CB$ ; the height  $CE$ , at which the Mercury stands in the wider Leg  $CB$ , is greater than the height  $CD$ , at which it stands in the narrower Leg  $CA$ .

On the contrary, Water stands higher in the narrower Leg, than in the wider.

*Exp. III. Fig. 7.*  $ABCD$  represents a rectangular plane of Glass, which makes one side of a wooden Box. On the inside of this is another Glass plane of the same size, which at the end  $AC$  is prest close to the former, and opens to a small Angle at the opposite end  $BD$ . When Mercury is pour'd into this Box to any height as  $CE$ , it insinuates it self between the two Glass planes, and rising to different heights between the Glasses where the opening is greater or less, it forms the common Hyperbola  $CGF$ ; one of whose Asymptotes  $EF$  is the line on which the Surface of the Mercury in the Box touches the inner Glass; the other is the line  $AC$ , in which the Planes are join'd. This Hyperbola being carefully examined by Mr. *Hanksbee* and

and my self, the Rectangle  $E H G$ , wheresoever taken, proved always equal to it self, to as great an accuracy as could be expected, when the Planes were opened to any considerable Angle: But when the opening was very small, the inequalities of the Planes, though the best I could procure, bearing a greater proportion than before to the distance between them, occasion'd a sensible variation. Which, by the way, I take to be the reason, why the Ordinates found by the late Mr *Hanksbee*, in examining the Curve produced in a contrary situation, upon dipping two Glass Planes so join'd into Spirit of Wine, do not answer to those of the Hyperbola.

*Exp. IV. Fig. 8.*  $A B$  is a perpendicular Section through two Glass Planes join'd at  $A$ , and open'd to a small Angle at  $B$ .  $C$  represents a pretty large drop of Mercury, the larger the better, which, being made to descend as far as  $C$ , by holding the Planes in an erect posture, with the end  $A$  downwards, retires from the contact of the Planes to  $D$ , upon inclining the Planes towards an horizontal Situation; and the distance  $C D$  becomes greater or less, as the Planes are more or less inclin'd towards the Horizon.

A drop of any Oily or Watery Liquor moves the contrary way, as has been shewn by the late Mr. *Hanksbee*.

*Exp. V. Fig. 9.*  $A B$  is a Tube open at both ends, and a Foot or two in length, whose lower part is drawn out into a fine Capillary at  $B$ . This Tube being fill'd with Mercury, the whole Column of Quicksilver will be sustain'd in it, provided the Capillary Tube at  $B$  be sufficiently small. But if the Mercury in the end  $B$  be suffer'd to touch any other Mercury it runs all out of the Tube. If, without letting it touch any other Mercury, a small part of the end  $B$  be broken off,

the Mercury will run out, till it comes to some lesser height as B C, at which it will again stop, the height B C being nearly in a reciprocal proportion to the Diameter of the small end of the Tube.

The Seventh Experiment in *Phil. Trans.* N<sup>o</sup>. 355 is the Reverse of this.

*Exp. VI. Fig. 10.* Is the same in substance with the former, but made with a large Glass Funnel A B, instead of a Tube.

The Reverse of this in Water is the thirteenth Experiment in the same Transaction.

In all these Experiments it is easily seen, that the Effect is owing to the difference between the two Attractions, by which Mercury tends to Glass and to its own body; they being always opposed to one another, so that a particular Explication is no way necessary. But perhaps it may save some little trouble to the Reader, to remove the following Objection, which will readily occur to him.

In the Experiments brought to demonstrate the fourth Proposition, the Globule of Mercury adheres to the Glass in a plane Surface, which cannot be done without encreasing the Surface of the Globule, and consequently removing some of its Particles from the contact of one another. If therefore they tend more strongly to one another than to the Glass, why do they not recede from the Glass, and assume a figure perfectly spherical, that they may all have the greatest possible contact with each other?

To this we may answer, that the Power, by which Mercury is attracted either by Glass, or by other Mercury, is proportional to the attracting Surface; and therefore, though, *ceteris paribus*, the tendency of Mercury to Glass is not so strong as its tendency to other Mercury, yet in this case a much greater number of  
Mer-

Mercurial Particles coming into contact with the Glass, than what recede from the contact of one another, it is no wonder, that the Attraction of the Glass prevails, and causes the Globule to adhere to it. For the number of Mercurial Particles which lose their contact with the other Mercury, is no more than what makes up the difference of Surface, which arises from changing the figure of the Drop: whereas the Particles, which by this means come to adhere to the Glass, are all those that constitute the plane Surface, in which the Globule touches it.

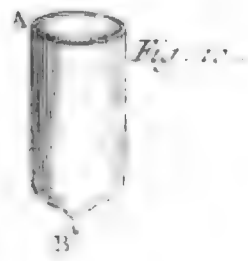
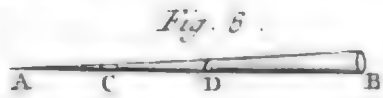
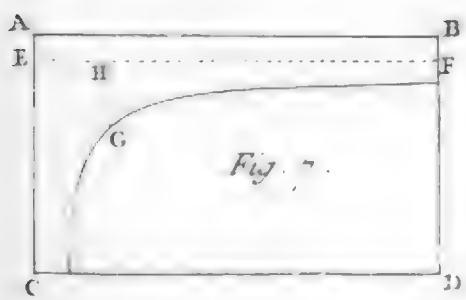
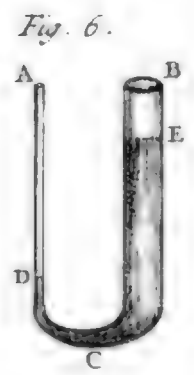
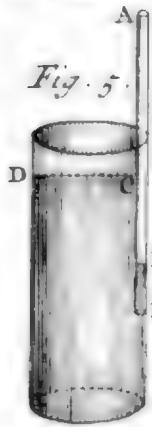
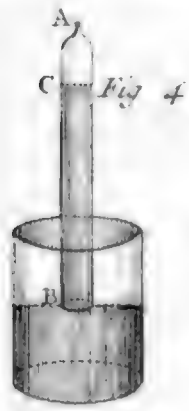
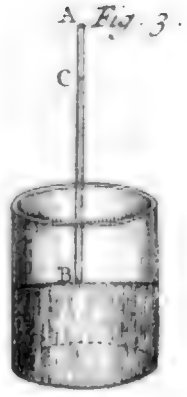
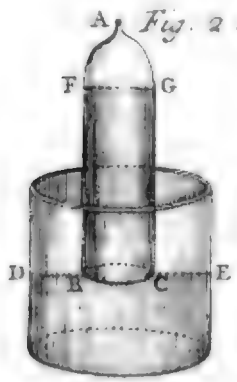
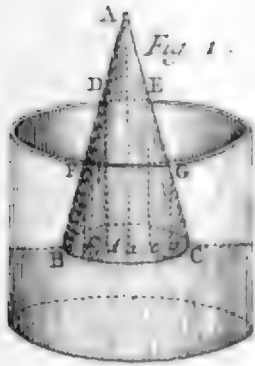
Which Consideration ought likewise to be apply'd to the Suspension of Quicksilver in Glass Tubes, either at extraordinary heights in the open Air, or at lesser heights in a *Vacuum*, as above mention'd. For the top of the Tube being Spherical, or nearly so, it will be found, that the contact of the Mercury with the extremity of the Tube, is to the contact with other Mercury, which would be gain'd by its leaving the Top of the Tube and descending a very small space, in a *Ratio* infinitely great; and consequently that the contact of the Mercury with the top of the Tube is one cause of its Suspension.

*Coroll 1<sup>st</sup>.* From this Proposition it appears, that in a Barometer made with a narrow Tube, the Quicksilver will never stand at so great a height as in a wider. Which accounts for the *Phenomenon* so often mention'd in the Yearly History of the Royal Academy of Sciences at *Paris*, by *Mont. De la Hire*; that in the Barometer, which he constantly made use of for his annual Observations, the Quicksilver did not rise so high, as in another he kept by him, by about three Lines and a half, which is near a third of an Inch our Measure: For he tells us, that the Tube of his Barometer is very small. So that there is no need to have recourse to any  
pecu-

peculiarity either in the Quicksilver or the Glass of which that Tube was made; or to an unperceived remnant of Air left in the Tube, from some of which causes that Effect and some others of the same kind were imagined to proceed.

*Cor. 2d.* In a Barometer made with a small Tube, the Mercury will rise and fall irregularly. For, as the height of the Mercury depends partly upon the Diameter of that part of the Tube that touches the upper Surface of the Mercury, it is plain, that the unavoidable inequalities in the Diameter of the Tube will be more considerable, in respect to the whole Diameter; and consequently will affect the height of the Mercury more in a small Tube than in a wider. And this I take to be the reason, why it is so very difficult not to say impossible, to make two Barometers, which shall exactly agree in the height of the Quicksilver in all constitutions of the Air, especially if the Tubes be very narrow. This irregularity is still more considerable in the Pendent Barometer, in which the Quicksilver moves through a large space, in order to make a small alteration in the length of the Column suspended: The same consideration is easily extended to those Levels, that depend upon the rising of Mercury to the same height in the opposite Legs of a bent Tube; an Instrument of which kind has been lately offer'd for the service of the Publick. And as the effect is just contrary in Levels made with Water or Spirit of Wine, due regard ought to be had to this Property in the construction of those Instruments, by making the Tubes sufficiently wide, in order to diminish the Error as much as possible.





III. *Part of a Letter from Dr. Rich. Richardson, to Will. Sherard, LL. D. & R. S. S. giving a relation of a wonderful Fall of Water from a Spout, upon the Mores in Lancashire.*

I Had an opportunity when in *Lancashire* of visiting a second time a vast breach in the Ground, which was made by a Spout, which fell upon *Emott-more*. The account I took of it when I first saw it, I put into Writing; and upon a second Inspection, finding it to be pretty exact, I thought a Transcript of it, would not be ungrateful to you, which you may communicate to your Friends, and make what use of it you please. You may depend on it as true.

Tho' our printed Voyages of several parts of the World furnish us with frequent accounts of damage done at Sea by Spouts of Water, yet such rarely happening at Land, induc'd me to take the following Relation of a remarkable one, which fell on *Emott-more*, nigh *Coln* in *Lancashire*, on *Tuesday* the 3<sup>d</sup> of *June*, 1718. about ten in the Morning: when several Persons who were employ'd in digging *Peat* nigh the place where this Accident happen'd, upon a sudden were so terrify'd with an unusual noise in the Air, that they left their Work and ran Home, which was about a Mile from the Place: But to their great surprise they were intercept'd by Water; for a small brook in the Way was risen above six foot Perpendicular in a few Minutes time, and had overflown the Bridge.

It is to be observ'd, that there was no Rain at that time on *Emott-more*, only a Mist, which is very frequent

quent upon those high Mountains in Summer time. There was a great Darkneſs in the Place where the Water fell, without either Thunder or Lightning. (as I had my Information from an Eye Witneſs) The Meadows at *Wicclae* were ſo much floated that the like had not been ſeen in ſeveral Years before, tho' there it was a very bright Day.

Upon this account, I went to view the Place where the Water fell; tho' I believ'd this Inundation might proceed from an eruption of Water out of the ſide of the Mountain: ſuch being not unfrequent, where Lead or Coal have been dug, but neither have ever been ſought for here. Upon approaching the Place, I was ſtruck with unſpeakable Horror. the Ground was torn up to the very Rock, where the Water fell, which was above Seven Foot deep, and a deep Gulf made for above half a Mile, and vatt heaps of Earth caſt up on each ſide of it, ſome pieces remaining yet above twenty Foot over, and ſix or ſeven Foot thick. About ten Acres of Ground were deſtroy'd by this Flood. The fiſt Breach where the Water fell is about ſixty Foot over, and no appearance of any Eruption, the Ground being firm about it, and no Cavity appearing. I muſt not forget to mention, that the Ground on each ſide the Gulf was ſo ſhaken, that large *Chafmes* appear'd at above 30 Foot diſtance, which a few Days after I obſerv'd the Shepherds were filling up, leaſt their Sheep ſhould fall into them.

IV. *An Account of the Phænomena of a very extraordinary Aurora Borealis, seen at London on November 10. 1719. both Morning and Evening.* By Dr. Edmond Halley. R.S. Secr.

UPON Tuesday, November 10. 1719. in the Morning, Jupiter applying to the Second in the Wing of *Virgo*, I got up about 5 of the Clock to observe him, and having had the Satisfaction to see my Calculus perfectly well answer the Heavens, I found certain white Streaks in the Sky, seeming nearly Perpendicular; which whilst I considered them seemed instantly to vanish, and soon after others came as instantaneously in their room. I began to imagine that this was likely to be some part of the *Phænomena* of the *Aurora Borealis*. But there appearing nothing like that luminous Arch which we have of late so often seen in the *North*, I knew not what to think; till looking up towards the *Zenith*, I perceived an entire *Canopy* of such kind of white *Striae*, seeming to descend from a white Circle of faint Clouds, about 7 or 8 degrees in Diameter, which Circle sometimes would vanish on a sudden, and as suddenly be renewed. I observed that the Center of this place of Concourse was not precisely in the *Zenith*, but rather 14 degrees to the Southwards thereof; which I was well enabled to estimate by a Star, which on each return thereof shewed its self about the Center of the Circle. This Star is the 33<sup>th</sup> Star of the *Great Bear* in *Tycho's* Catalogue, whose distance from the Pole at this time is  $52\frac{1}{2}$  degrees, and which about half an hour past Five that Morning past the Meridian, so that those Rays centred very nearly on the Meridian it self. It

a very entertaining Sight, till such time as the Day-break began to obscure these Lights, which were but faint, though sufficiently distinguishable. They came none of them lower than to about 30 or 40 degrees of Altitude, and seem'd not to have ascended from the Horizon. The Sky was perfectly Serene and Calm, which seems to be one of the concomitant Circumstances attending the *Aurora Borealis*, of which this was certainly a Species. For the Night following a Neighbour gave me notice of a strange streaming of Lights seen in the Air, which thereupon I attended from the Hours of 9½ to 11, when a Fog came so thick as to put an end to my Prospect. But during that whole time there ascended out of the *E. N. E.* and *N. E.* a continued succession of whitish *Striæ*, arising from below; and after changing as it were into a sort of luminous Smoke, past over head with an incredible swiftness, not inferiour to that of Lightning; and as it past, in some part of its Passage seemed as it were guilded, or rather as if the smoke had been strongly illuminated by a blaze of Fire below. Some of the *Striæ* would begin high in the Air, and a whole set of them subordinate to one another, like Organ Pipes, would present themselves with more rapidity than if a Curtain had been drawn from before them; some of which would die away where they first appeared, and others change into a luminous Smoke, and pass on to the Westwards with an immense Swiftness. And I am of opinion, that had it not been for the Moon, then ten Days old and very bright, this for the time would have been reckoned as considerable an Appearance as that of the 6th of March, 1716.

V. *A Relation of the same Appearance, seen at Cruwys Morchard in Devonshire. Being part of a Letter to Sam. Cruwys, Esq; R. S. S. and by him Communicated to the Royal Society.*

**Y**OU have doubtless been surprized again afresh by the wonderful Lights which have been seen several times of late like those described in the *Philosophical Transactions*; seen on *March 6. 1716.*

*Monday the 26 of October,* between 7 and 8 in the Evening, I saw some small appearance of it, *viz.* 3 or 4 large Coruscations in form of Pyramids, of reddish Colour inclining to Yellow, which rose about 50 degrees above the Horizon, and continued but few Minutes. But the North part of the Hemisphere was very bright and red all the Evening both before and after, till Ten, if not longer.

*Tuesday, Novemb. 10.* These Lights were seen again about 4 in the Morning, of which some say (to use their own Expressions) that the Element opened sometime at one place, then at other; from whence came great shining Lights that continued a while. and then went away by degrees, and the Holes closed up again. This continued till Day break.

The Evening following coming from *Tyverton* about half an hour after Eight, I saw the North part of the Horizon very light and reddish (notwithstanding the Moon being about 10 Days old, was then in or past the Meridian, and shone very bright) in a short time the streaming luminous Rays began to appear very plain, some in one shape, some another; many of them

like Cones or Pyramids, but most of them badly terminated ; some of which mounted very high, almost to the Zenith, to which place, or near, they all or most, seemed to point. Shortly after there appeared a long Streak of about 30 Degrees, parallel to the Horizon and about 15 or 20 distant from it, and about 2 or 3 broad, but badly terminated and of a fiery red Colour: which sent out some of the same streaming Beams towards the Zenith. About 6 or 7 Minutes after there appeared (somewhat sudden) a Circular Figure like an Iris, but twice as broad, of a pale Colour. The East part was terminated by the Horizon at full East, if not something to the South, and the West End about North West ; the upper part of its Arch being 50 or 60 Degrees high, great numbers of luminous Rays darted from it upward and downwards, (or else passing cross it from the Horizon) at oblique Angles pointing to the Zenith, especially from the North East part. This continued, as near as I can guess (by the distance I rode) about 8 or 9 Minutes, when it divided and disappeared. After an Interval of 3 or 4 Minutes, another Iris-like Figure appeared, (of a Colour (as it seemed) paler than any of the streaming Lights had been) whose Diameter was less than that of the former, and shewed more than its Semicircle above the Horizon, the upper part of its Arch approaching near the Zenith. I could not observe any Rays to pass from, (or a-cross) this as from the other. The Centre of this last was much more to the West than that of the first. After the continuance of a Minute or two, it began to break in the upper part of its Arch and shining Particles being sent out from both its broken Ends towards the Zenith, (to which they were near before) or rather a little beyond it to the South or South West, they there formed a sort of *Corona*, curving and bending somewhat like Flames reverberated on the Arch

of

of an Oven : tho' this expresseth it but badly, yet I know not how to describe it better. It seemed to me and others to be finely tinged with various Colours, Red-Yellow and Blueish, &c. and sent out every way from it (except South and South-west) long flame-coloured Rays. After this had continued about two Minutes, its shining Light abated, and it left behind it for some Minutes, something like a whitish Cloud (like in Colour to what the Light on the 19<sup>th</sup> of *March* last left behind it, after the fiery Particles were extinguished, but thinner).

*N. B.* All this while the Moon shone very bright, from which this *Corona* was not very far distant, perhaps not twenty Degrees, to the North East. After this there continued to be sent up many fiery Coloured or Yellowish streaming Lights, sometimes more, sometimes less, now here, now there, all along the North part of the Hemisphere, but mostly from the North North East. All this while something like small whitish Clouds (which to me seemed to move towards the Zenith, or to point a little more Southward, but disappear'd as they approached the Moon) were carried very swiftly, and at very short intervals, mostly coming from the East and North East, but many also from North and North West. We took but little notice of this at first, supposing it had been nothing but the reflection of the other Lights, or the shadows of the Clouds (whereof the North parts were pretty full) as the streams of Light pass behind them : But at last we observed that when the Lights at any time abated, these kind of Clouds continued to fly as swift and frequent as ever. This I saw till Twelve or One next Morning : many others saw it next Morning till almost break of Day, when it appeared much more red and fiery than it was in the Evening ; the Moon perhaps  
being



being then set. Some People observed tall Cones to arise in the East, and to be carried to the West pretty swiftly in an erect Position, but I saw them not. It has been represented here in all sorts of Appearances, Armies, Battles. &c. and has put abundance of People in dismal Frights: But I had not an Imagination strong enough for it, &c.

*Novemb. 16.*

*Will. Maunder.*

VI. *A further relation of the same Appearance as seen at Dublin, communicated to the Publisher by an unknown Hand.*

**I**T is with pleasure that I now give you the trouble of reading the ensuing Account of the surprizing Lights which on *Tuesday* the tenth of *November* we saw in the Northern Semicircle of our *Horizon*.

The Afternoon was very Calm and Serene; about six in the Evening the Sky was ting'd with a strange kind of Light, and some Streams began to project from the North and North East. One of them arose about N by E. and was nearly a Subtense of an Arc between that and S. W. by West; it was a little curvated toward the Sun, and what I saw of it (for the North part of the *Horizon* was conceal'd by Houses) very much resembled the tail of a Comet: About the same time there was one or two which arose in the East, ascending obliquely so as to leave the *Zenith* several Degrees to the Northward,

These *Striae* continu'd to appear and disappear alternately till toward Eight in the Evening; they were *Pyramidal*, and their *Vertices* frequently projected several Degrees to the South of our *Zenith*.

Between

Between nine and ten I was agreeably surpriz'd with a kind of Coruscation, or Flashing, that shew'd it self between twenty and sixty Degrees from the *Zenith*, in the South or South by West; and which from four or five, sometimes from more places at once, darted with a Velocity not much inferior to that of Lightning; and by interfering with each other produc'd a beautiful Tremour or Undulation in that subtile *Vapour*, which I cannot better illustrate, than by comparing it to the Beams of the Sun, reflected on a Ceiling from the Surfaces of two or three Basins of Water: These *Waves* of Light were only visible at the instant of Coruscation, and were of a pale whitish Colour, somewhat resembling the flashes produced by the violent agitation of Quicksilver in an Exhausted Receiver; but so strong that a Gentleman who about that time was in a Room by himself, without a Candle, assur'd me he took it for common Lightning: Thus it continued incessantly for more than an Hour, during which time several lucid *Areas*, like little Clouds, discover'd themselves in the pure Sky, and after they had continu'd about five or six second Minutes, as near as I could guess would instantaneously disappear; most of them pretty much resembl'd a very thin white Smoke or Vapour illuminated by the Full Moon.

About three quarters past Ten, this Vapour was almost spent, or by a brisk Gale at South by West dispers'd and driven to the Northward; at which time, between the West and North, a vast body of it, like a very bright Flame-colour'd *Crepusculum*, seem'd to be fix'd: From this Basis several Beams or *Striae* of shining matter were at uncertain intervals, emitted; and tho' it was not so sensible to the Eastward of the North, yet several mighty Pillars were also ejected from thence; One, which if I mistake not, arose directly under  
the

the Pole, was, above all others that had preceded it, both as to its Magnitude and Density so surprizing, that I'm perswaded the smallest Print might have been read by the Light thereof, had not that of the Moon, which shone very bright, pretty much effac'd it: 'twas ting'd with a kind of Yellow and Violet Colour. In about two or three Minutes it died away, and was succeeded by others of an inferior Order: It was now about a quarter past Eleven of the Clock, and nothing but repeated *Phases* of the same Spectacle offering themselves to View; the Vibrating Motion had ceased; the Vapour shewed it self no longer in lucid *Areas*; the streams of Light were not so frequent, and those more languid than before; and the bright *Aurora* having settled nearer the *Horizon*, I concluded the *Scene* was at an End, and accordingly gave over the quest of new *Phænomena*, with only observing that about N. E. there appear'd some Clouds that reflected an unusual kind of reddish Light. Others, who thro' a Principle of Fear sat up longer than I did, represent the End with very surprizing Circumstances; but as it escap'd the Eyes of those who were best qualified to oblige the World with an History of it, so I despair of adding any thing that may be satisfactory: and there were no doubt many Circumstances of Weight that I did not observe; for the wonderful Variety this *Phænomenon* afforded, and the frequency and suddenness of its Alterations, made it impossible for the Eye of any single Person to trace it.

On *Tuesday* the 24<sup>th</sup> of *November* we had the same *Phænomena* repeated, tho' not with the same Variety: About a quarter past ten at Night, a vast Body of shining matter was collected between N. W. by West, and N. by E. in the form of the Segment of a Circle, whose Center was about 25 or 30 Degrees below the  
*Horizon*;

*Horizon*; from its *Periphery* a few short *Pyramidal* Streams, of the same luminous Vapour, ascended by a slow and nearly uniform Motion, and were exceeding rare so as not to efface the smallest of the fix'd Stars; and in a Minute or two vanish'd: It was very remarkable that the Light which that Collection of Vapour emitted was so great, that in the otherwise very dark Night, I cou'd thereby (at three quarters past Ten) read the Title of the last *Philos. Transact.* which then happen'd to lye on my Desk; and at four or five Yards distance see the smallest Books in my Study.

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VII. *An Account of another very considerable Aurora Borealis observed at Streatham in Surrey, by Mr. Thomas Hearne; and Communicated by Coll. Francis Nicholson, R. S. S.*

HAVING seen Dr. *Halley's* Account of the Coruscations in the Morning and Evening of *Novemb. 10th.* (and the Letter annexed to it from *Devonshire*) I had the Pleasure to find the Observations made upon that Appearance very agreeable to what I had myself observed the Evening of that Day; and to what I did not at that time observe, but had an opportunity of observing in the Night of *Dec. 11.* I believe much more plainly than Dr. *Halley* had in the Night of *November 10.*

*Dec. 11th.* About one a Clock at Night (or rather in the Morning of *Dec. 12th*) I was called to observe Coruscations which appeared of a much different Colour, and in a very different manner from any I had before seen.

The streams of Light that darted upwards from the Horizon seemed to be at considerably a greater distance, but not at all in less quantity than those of Nov. 10th. But their meeting in a Point near the *Zenith*, and there forming a kind of *Canopy*, was what was particularly remarkable in the *Manner* of the Coruscations now different from those of Nov. 10.

The streams of Light rose from the Horizon only towards the North, and on each hand towards N. East and N. West : But near the *Zenith* a Canopy was formed of streams of Light meeting in a Point, not only from those Quarters, but also from the South, &c. Only to those Points they extended downwards from the *Zenith* but a little Way, and were neither in so great quantity nor quite so bright as those Northwards. At first I thought the Point in which the Streams met was exactly the *Zenith*, but upon observing it something longer, I found it was not so, but a few Degrees to the South of the *Zenith*. The streams of Light near the *Zenith*, which formed this Canopy, were of a pretty bright Colour, and in great Quantity, and darted very swiftly.

On each side of the N. towards E. and W. but not exactly in the N. it self (at least when I saw it) from about 10 or 15° to 40 or 50° above the Horizon, the Streams were of a glowing red Colour, whereas all that I had ever seen before were very pale. The redness was like that of a burnt Brick, and nearest of any thing I have seen to the Colour, which remained for a few Minutes, like that tract through which the Meteor passed in the Spring.

The Streams appeared of this fierce Colour when I first saw the Coruscations, and continued so for some time, till the redness by degrees wearing off, in about  $\frac{1}{2}$  of an Hour they appeared of the usual Paleness, when

when I left them still forming a Canopy near the Zenith, as is above described.

The Air was very Calm and Serene, not a breath of Wind stirring; as I remember it was also *Nov. 10th.*

The Moon was now a Day or two older than it was on *Nov. 10th.* and a good deal further to the W. than when I saw the Coruscations that Night being then near full South. She had now round her what is commonly called a Burr larger than ordinary, and several very lucid Clouds at a little distance.

### VIII. *Nuperae Observationes Astronomicae cum Regia Societate communicatae.*

CUM in Num. harum *Transactionum* 357<sup>mo</sup>. Observationes nonnullas Planetarum ac Lunæ conservari dignissimas in unum congeessimus, ac probante Societate nostra edidimus; liceat paucula folia hujusmodi collectionibus in sequentibus quotannis consignari. Nuperae autem quas habemus Observationes hæ sunt.

1718. *October* 10°. mane, applicabatur *Jupiter* ad Fixas Telescopicas, quarum loca, occasione primæ apparitionis Cometæ anni 1680, (de quâ vide *Phil. Transf.* N°. 342) sedulo inquisivit Rev. D. *Pound*, ac nuper verificata nobiscum communicavit, una cum accuratâ observatione transitûs Jovis juxta eas hac vice, ac deinde alterâ *Febr.* 11°. statim ab oppositione Solis & Jovis. Incunte autem *Januario* 1719. loca stellarum sic se habuere.

|                   | Long.         | Lat. Bor. | Long.                       | Lat. Bor.    |
|-------------------|---------------|-----------|-----------------------------|--------------|
| <i>d</i> $\Omega$ | 29°. 59'. 43" | 1. 7. 50  | <i>a</i> $\pi$ 0°. 25'. 41" | 1°. 28'. 54" |
| <i>e</i> $\pi$    | 0. 6. 13      | 1. 10. 18 | <i>x</i> $\pi$ 0. 5. 43     | 0. 51. 56    |
| <i>c</i> $\pi$    | 0. 3. 13      | 0. 32. 50 |                             |              |

Ubi notandum stellas *d* & *e* eandem præcisè hoc seculo fortiri declinationem, *x* vero exiguam esse stellulam in priore descriptione ob parvitatem omissam.

Jam *Octob.* 9°. 17<sup>h</sup>. 50' T. æq. Jovis limbus orientalis attingit lineam stellas *e* & *c* jungentem, simul centrum ejus distabat ab *e* 21'. 20" & à *c* 16'. 25". Statimque aberat à *d* 19'. 35". Parvula *x* Jovi proxima latuit, luce ejus obumbrata.

*Decemb.* 11°. 18<sup>h</sup>. 30. T. æq. Saturni centrum distabat à  $\mu$  *Librae Bayeri*, 28'. 32", & Fixâ Borealius erat 4'. 31". Hinc conclusit D. Pound Observator Saturni locum  $\eta$  10°. 41'. 10", cum Lat. Boreal. 2°. 16'. 43".

1719 *Feb.* 11°. 6<sup>h</sup>. 56<sup>1</sup>/<sub>2</sub> T. æq. Jovis retrogradi centrum distabat à stella *d* superius descriptâ — 10'. 42"

6. 58<sup>1</sup>/<sub>4</sub> Idem centrum distabat ab *e* — 6. 7

9. 37<sup>1</sup>/<sub>2</sub> Iterum distantia capta à *d* — 10. 9

9. 43<sup>1</sup>/<sub>2</sub> Iterum ab *e* — 6. 11

9. 49<sup>1</sup>/<sub>2</sub> Jovis centrum distabat ab *a* — 25. 21

9. 58<sup>1</sup>/<sub>2</sub> Idem centrum à parvula *x* — 24. 38

Circa Horam septimam Jovis limbus orientalis attingit lineam per *x* & *e* productam; Jupiter itaque tunc habuit  $\eta$  0°. 6' cum Latitudine Boreal. 1°. 16'. 30".

Deinde, *Feb.* 13°. 8<sup>h</sup>. 0'. T. æq. Declinatio centri Jovis, Micrometro mensurata, Borealius erat eâ stellæ utriusque *d* & *e* 11'. 37", & 8<sup>h</sup>. 20' eadem differentia inventa est 11'. 36". Horâ vero 8<sup>h</sup>. 48' centrum Jovis distabat ab *e* 17'. 40'.

*Apr.* 22°. 10<sup>h</sup>. 45'. T. æq. Saturni centrum sequebatur  $\mu$  *Librae* 4<sup>1</sup>/<sub>2</sub> Temp. sive 1'. 8" Asc. Rectæ. Micrometro autem Borealius inventus est Fixâ 35'. 25". Stella autem in *Catalogo Britannico* tunc habuit,  $\eta$  10°. 16'. 8". Lat. Bør. 2°. 3'. 54".

*Maii* 16°. 8<sup>h</sup>. 00' T. æq. x sequebatur *Cor Leonis* 1°. 34<sup>1</sup>/<sub>2</sub>' Ascensionis rectæ; Borealior autem erat stellâ illâ 0'. 41<sup>1</sup>/<sub>2</sub>'. Temporis, hoc est, 10'. 7" Arcus cœlestis.

Eâdem nocte, 15<sup>h</sup>. 18' T. app. Observavit D. *Stephanus Grey Martem*, ratione Ascensionis rectæ, sequi stellam in *Cauda Capricorni* orientalem 16'. 15"; simul non nisi 0'. 11". australior erat quam *Fixa*.

*Junii* 7°. 10<sup>h</sup>. 15'. T. app. *Jupiter* directus iterum reversus est ad stellas Telescopicas prædictas, & tum sequebatur stellam d. 0'. 35" Ascensionis rectæ, & 10<sup>h</sup>. 30' distabat fixa à limbo *Jovis* proximo 4'. 18".

Postridie *Junii* 8°. 10<sup>h</sup>. 20', *Jupiter* sequebatur stellam alteram e 1'. 30' Ascensionis rectæ, ac statim distantia limbi *Jovis* proximi à stella capta est Micrometro 7'. 30".

*Julii* 5. 8<sup>h</sup>. 26'. T. app. Conjungebantur arcuè *Jupiter* & *Venus*, quæ tum Borealior præcedebat *Jovem* secundum Ascensionem rectam 1'. 20": Centrum autem distantia ex decies repetitis media, capta est 13'. 36". Hæc tria *Londini* observata communicavit harum Scientiarum eximius Cultor D. *Martinus Folkes*, R. S. Soc.

*Aug.* 3. 12<sup>h</sup>. 20' T. æq. *Mars* pene Acronychus sequebatur stellam  $\tau$  *Aquarii* *Bayero* 10'. 58" Temporis, sive 2°. 44'. 57" Ascensionis Rectæ. Erat autem fixâ *Mars* Borealior 0'. 36" tantum; unde concessio loco stellæ *Britannico* fit locus *Martis* observatus x 7°. 10'. 10" cum latitudine Australi 0°. 38'. 10".

*Aug.* 10°. 11<sup>h</sup>. 50' T. æq. *Mars* sequebatur fixam minorem quæ præcedit  $\tau$  *Aquarii* 1°. 39'. 30" ratione Ascensionis rectæ; Australior vero quam fixa 10'. 42".

*Aug.* 16°. 7<sup>h</sup>. 18'. T. æq. *Spica Virginis* præcedebat *Veneris* centrum 5<sup>1</sup>/<sub>4</sub>" secundis temporis, sive 1'. 20" Ascensionis rectæ, australior Planetâ 18<sup>1</sup>/<sub>2</sub>" temp. sive 4'. 35".

*Aug.* 17°. *Mars* pridie Acronychus ac Terris proximus observatus est ad duas stellulas contiguas, Parallaxis  
ejus



ejus investigandi gratiâ, juxta methodum à D. *Cassino*, in libro de Cometa anni 1680, exhibitam, Unde *Martis* Parallaxin eruere in *Transact.* proximâ conabimur. Harum vero stellarum borea tum temporis locum habuit  $\times 3^{\circ}. 5'. 50''$  cum Latitudine australi  $6^{\circ}. 6'\frac{1}{4}$ : altera vero Australior habuit  $\times 3^{\circ}. 5'. 30''$ , cum Lat. Aust.  $6^{\circ}. 10'\frac{1}{4}$  proximè. Horâ vero  $10^h. 40'$ . T. æq. Australem sequebatur *Mars*  $41'$  min.  $40''$  Ascensionis rectæ, eâque adhuc Australior erat  $7'. 50''$ .

*Sept.* 18.  $9^h. 20'$ . T. æq. *Mars* visus est præcedere stellam in *Catalogo Britannico* Aquarii  $53^{ia}$   $3'. 45''$  Temporis, sive  $56'. 24''$ . Ascen. Rectæ; simulque Stella Borealiore erat limbo *Martis* boreo, non nisi unâ Planetæ diametro. Locus stellæ  $\approx 29'. 57'\frac{1}{2}$  Lat. Aust.  $4^{\circ}. 48'\frac{1}{2}$ .

*Octob.* 30. Vesperî  $5^h. 45'$ . T. app. *Mars* proximus stellis duabus contiguis ad *h*  $\approx$  *Bayero*, quæ sunt  $\approx 73^{ia}$  &  $74^{ia}$  *Catal. Brit.* Præterierat rectam per easdem duæ, eratque angulus ad *Martis* centrum ad sensum rectus: Borea vero stellarum eandem habuit declinationem cum limbo Planetæ austrino.  $5^h. 53'$  distantia stellæ à centro *Martis*  $2'. 30''$ .  $5^h. 56'$  centrum *Martis* distabat à tertiâ & Australiore ad *h*, sive  $75^{ia}$  Aquarii,  $17'. 04''$ .  $6^h. 18'$  distantia centri à Boreâ sive  $73^{ia}$  erat  $3'. 5''$ . Hinc concludere licet *Martem*, horâ  $3^h. 30'$  proximè, stellæ Boreæ conjunctum fuisse, eamque uno tantum minuto ad Boream reliquisse. Fixæ autem locus è *Catalogo Britannico* tunc erat  $\times 10^{\circ}. 29'. 00''$  cum Lat. Aust.  $1^{\circ}. 40'\frac{1}{4}$ .  $74^{ia}$  vero habuit  $\times 10^{\circ}. 29'. 50''$  cum Lat. Aust.  $1^{\circ}. 44'\frac{1}{4}$ .

*Novemb.* 16.  $19^h. 18'$ . T. æq. *Venus* præcedebat *Lancem Libræ* Austrinam  $3'. 13''$  Temp. sive  $48'. 23''$  Ascen. Rect. simulque fixâ borealius erat centrum *Veneris*  $7'. 45''$ . *Venus* quasi Stationaria apud Nodum ejus Ascendentem.

*Decemb.*

*Decemb. 3<sup>o</sup>. 19<sup>h</sup>. T. æq. Saturnus præcedebat tertiam ad*  
*ζ Libræ, sive Libræ 29<sup>am</sup>. Cat. Brit. 0'. 46" Temp. sive 11'. 32"*  
*Afc. Rect. Erat autem fixâ Australior 15'. 29". dif-*  
*ferentiâ per Micrometrum captâ. Unde Saturni locus*  
*in 20. 25<sup>1</sup>/<sub>4</sub> cum Lat. Bor. 2<sup>o</sup>. 5<sup>1</sup>/<sub>4</sub>.*

### *Observationes Lunæ & Eclipsium.*

In dicta *Transact. N<sup>o</sup>. 357. pag. 852.* Observationem dedimus Eclipses Lunaribus anno 1717 Martii 15<sup>o</sup> P. M. St. vet. apud *Cambridg Nov-Anglorum* habitam; apud nos vero ob Nubes inconspicuam. Desiit autem Eclipsis ibidem 11<sup>h</sup>. 42<sup>1</sup>/<sub>2</sub>, neque alia ejus tum temporis suppetebat observatio. Postea vero arte Nauticâ & industriâ inter primos insignis Dom. Candler Navarcha Regius, ex *America* attulit & nobiscum communicavit ejusdem Eclipses phases *Limæ Peruvia* à Dom. Petro Peralta, Mathematico Regio multis titulis claro, observatas, Typisque ibidem impressas. Initium autem Eclipsis ponit *Limæ* 8<sup>h</sup>. 41'. 8". Finem vero 11<sup>h</sup>. 19'. 55". Simul laudatus D. Candler propriam observationem, ad Insulam quam *Virgine Gorda* vocant captam, concessit, Ibi desiit Eclipsis 12<sup>h</sup>. 13'. P. M. Fine per cælum sudum distinctè viso. Postremo inter Acta Regiæ Scientiarum Academiæ *Parisiensis* istius anni, comperimus duas & quidem satis conformes hujus Eclipses observationes, alteram à D. Cassino, alteram à D. de la Hire in Observatorio Regio captas: Hic Initium æstimavit 13<sup>h</sup>. 54'. Finem vero certius 16<sup>h</sup>. 38'. 10". At Ille Initium 13<sup>h</sup>. 55' & Finem 16<sup>h</sup>. 38'. 25". Maxima obscuratio huic 7<sup>1</sup>/<sub>2</sub> Dig. illi 7<sup>1</sup>/<sub>2</sub> Dig.

Hinc ex Fine, in singulis locis ut videtur accuratius sumpto, proveniunt Longitudinum differentię inter *Parisios & Limam* 5<sup>h</sup>. 18'. 20", Inter *Parisios & Cambridg* 4<sup>h</sup>. 55".

4<sup>h</sup>. 55'. 50". Inter *Parifios* & Infulam *Virgine Gorda* 4<sup>h</sup>. 25'. 20". E quibus fi 9'. 40" subduxeris, provenient Longitudines ad occafum *Londini*, nempe *Lima* 77°. 10'. *Cambridg* *Nov Anglorum* 71°, ac denique Infulæ *Virgine Gorda* 63°. 55'; unde Infularum adjacentium fitus Geographici certo corrigi poterint.

Altera Lunæ Eclipsis ejufdem anni *Septembris* nono Vefperi, ab iifdem obfervatoribus & D. *Maraldo Parifis* confpecta eft. Finem *Londini* obfervavimus in ædibus Societatis Regiæ 7<sup>h</sup>. 26'. *Parifis* vero D. *Caffino* Finis 7<sup>h</sup>. 34'. 50", D. *Maraldo* 7<sup>h</sup>. 35'. 30", & D<sup>no</sup> *De la Hire* 7<sup>h</sup>. 34'. 15". Simul D. *Wurtzelbaur Noribergæ* eundem Finem vidit 8<sup>h</sup>. 10'. 45" Hinc confirmantur Meridianorum differentix *Londinum* inter & *Parifios*, præfertim ex obfervatione D. *Maraldi*, nempe 9'. 30"; uti & inter *Londinum* & *Noribergam* 44'. 45", quantam sæpius olim experti fumus. Porro quinto die poft Eclipsin, *Septembris* 14<sup>to</sup> vefperi, Luna occultavit Palilicium *Parifis*, obfervantibus figillatim DD. *Maraldo* & *Delisle* Juniore. Evanuit autem ftella è regione Maculæ *Grimaldi* five *Paludis Marcotidis*, Hora 9<sup>h</sup>. 11'. 35". Emerfit autem è limbo Lunæ obscuro 10<sup>h</sup>. 3'. 55". Hujus Occultationis obfervatio *Londini* habetur pag. 853. *Phil. Tranfa&*.

Obfervationes illas, in quibus Temp. æq. adhibetur, Rev. D<sup>o</sup> *Pound* acceptas debemus. Tubo autem quindecimpedali capta pro certiffimis habenda funt.

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